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INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

THE MANGANESE SITUATION FROM A DOMESTIC STANDPOINT

By J. W. Furness

The purpose of this circular is to show the degree of dependence of the United States upon foreign sources for the manganese required by its industries.

Properties.

Manganese belongs to that group of elements which includes iron, manganese, cobalt, and nickel. It is never found in the metallic state in nature, but generally occurs as oxide, silicate, or carbonate. Manganese is a crystalline, brittle metal, silvery white or grayish-white in color with a reddish luster. Its specific gravity is between 7.13 and 8.; atomic weight, 54.6; melting point, 1230° C.; boiling point, 1900° C.; electrical conductivity as compared with silver, 1 to 50.5. Its chemical properties are similar to those of iron. To a sodium carbonate bead in an oxidizing flame, manganese imparts a characteristic blueish green color; to a borax bead in an oxidizing flame it gives a purplish or amethystine color.

Manganese minerals.

Manganese occurs in nature in a great many combinations with various metals. The chief manganese minerals are described below.

Pyrolusite, also called peroxide, is the dioxide ( $MnO_2$ ), and constitutes the chief ore of commerce; when pure it contains 63.63 per cent manganese and 36.36 per cent oxygen. Its specific gravity is 4.73 to 4.86; hardness, 2 to 2.5; color, gray of steel, or black of iron. Usually the mineral is combined with small quantities of silica, lime, iron and barite. It sometimes is found in powdered form and in small grains, but more often is massive.

Psilomelane, the hydrated bioxide, has a variable composition. The approximate formula is  $4 MnO_2 + MnO + n H_2O$ . The content of metallic manganese ranges from 45 to 60 per cent. It is often associated with small quantities of barite and potash. Its specific gravity is 3.7 to 4.7; hardness, 5 to 6. Its color is black.



Braunite, the sesquioxide of manganese ( $Mn_2O_3$ ), is often associated with small proportions of silica. Its specific gravity ranges from 4.75 to 4.82; hardness 6 to 6.5; content of metallic manganese 64.3 per cent.

Manganite, the hydrated sesquioxide ( $Mn_2O_3 \cdot H_2O$ ), has a specific gravity of 4.2 to 4.4. Its hardness is 4; content of metallic manganese 62.5 per cent. It is brown in color and very friable.

Hausmannite, oxide of manganese ( $MnO \cdot Mn_2O_3$ ), has a specific gravity of 4.73 to 4.86; its hardness is 5 to 5.6; content of metallic manganese 72.1 per cent. It is brownish-black in color.

Wad, which is composed of oxides and hydrates in variable proportions, is an impure manganese oxide that grades into psilomelane. Its specific gravity is 3 to 4.3; hardness 1 to 6; content of metallic manganese, variable. It usually contains a high percentage of water, sometimes as much as 20 per cent. Its color is black or brown.

Rhodo-chrosite, carbonate of manganese ( $MnCO_3$ ) has a specific gravity of 3.45 to 3.6; its hardness is 3.5 to 4.5; content of metallic manganese 47.86 per cent. Its color ranges from light rose to dark rose.

Rhodonite, silicate of manganese ( $MnSiO_3$ ), has a specific gravity of 3.4 to 3.68; its hardness is 5.5 to 6.5; content of metallic manganese 4.86 per cent. It is rose colored.

Bementite, hydrosilicate of manganese, ( $2 MnSiO_3 \cdot H_2O$ ) has a specific gravity of 2.9. It is a dark pink in color.

Franklinite is a mineral containing iron, zinc and manganese; its color is black and it resembles magnetite. The only important occurrence is near Franklin Furnace, N. J.

Of all the minerals of manganese the only ones that have any merchantable value are the oxides and the carbonates. Small amounts of the silicates are used in the manufacture of silicomanganese and silicospiegel.

In addition to the minerals mentioned, a great number of the minerals of iron, notably the hematites, contain manganese, and are known as manganiferous iron ores and ferruginous manganese ores. 1/

#### Manganese Deposits

With the exception of a negligible quantity, virtually all the manganese minerals that are mined are oxides. With minor exceptions, the deposits of these minerals are of the sedimentary or residual types.

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1/ Descriptions of the various combinations of manganese or other minerals may be found in Bulletin 427, U. S. Geol. Survey, Manganese Deposits of the United States, by Edmund C. Harder, pp. 224 - 242.



## Metallurgy :

Pyrometallurgy is now the only practical method in vogue for extracting manganese from its ores. As manganese is highly volatile at the temperature required to reduce it to the metallic state, smelting losses are extremely high, and materially increase the cost of the reduced metal. To produce metallic manganese the ore must be smelted at a high temperature and a strong reducing action maintained. As this method reduces any iron in the ore, the resultant metal is an alloy of manganese and iron. The Goldschmidt process, which is based upon thermit action, is now used to produce metallic manganese. In it pure manganomanganic oxide mixed with aluminum, is used. The powdered aluminum is incorporated with the oxide and the mixture is brought to the required temperature. The amount of aluminum used is based on the total oxygen content of the purified manganese oxide, and is sufficient to produce sesquioxide of aluminum. Other processes for the manufacture of metallic manganese are the J. T. Jones (U. S. patents 1288422 and 1289799), and the Sternberg & Deutsch (English patent 13177).

Metallic manganese may be produced by hydrometallurgy based upon the reduction of the oxides to chlorides or sulphates. The resultant product is  $Mn_2O_3$ , which may be reduced to Mn by the Goldschmidt process.

From the standpoint of producers the metallurgy of manganese may be divided among three separate interests, as follows: (1) Manufacture of manganese steel; (2) the concentration of major manganese oxides for the use in further metallurgical manufacture, as a coloring agent in ceramic industry, in the manufacture of glass, and as a depolarizing agent in the manufacture of Leclanché cell; and (3) the use of manganese ore in the preparation of chemical compounds, used in medicine, sanitation and elsewhere.

## Uses

Upwards of 92 per cent of the manganese now utilized goes into the manufacture of steel. Under present practice, manganese is essential in the steel industry, and no substitute for it is known. For many of the minor uses of manganese there are substitutes. Some of the uses of manganese are as follows:

### 1. Alloys:

- Ferrromanganese (alloy of manganese and iron).
- Spiegeleisen (alloy of manganese and iron).
- Manganese steel (alloy of manganese and iron).
- Silicospiegel (alloy of manganese, iron and silicon).
- Manganese bronze (alloy of manganese and copper).
- Silver bronze (alloy of manganese, aluminum, zinc and copper).
- Alloys of manganese with aluminum, zinc and tin.

### 2. Oxidizers:

- Dry batteries.
- Leclanché cell.
- Decolorizer of glass.
- Drier of varnishes and paints.
- Preparation of oxygen on a small scale.
- Manufacture of disinfectants (manganates and permanganates).

### 3. Coloring materials:

Coloring glass, pottery, tiles and bricks.

Calico printing and dyeing.

Paints (brown; green; violet).

### Alloys

Five classes of manganese ore are utilized in the manufacture of iron and steel: (1) Manganese ores, (2), manganiferous iron ores, (3), manganiferous zinc residuum, (4) rhodochrosite and (5) small amounts of rhodonite. Fully 75 per cent of the consumption of manganese in steel manufacture may be attributed to the production of the manganese-iron alloys, spiegeleisen and ferromanganese.

Ferromanganese is an alloy of iron, carbon and manganese. The usual specifications are -

	<u>Per cent</u>
Manganese .....	78 - 82
Iron .....	8 - 15
Silicon .....	.5 - 1
Carbon .....	5 - 7
Phosphorus.....	.10 - .30
Sulphur .....	under .03

In the manufacture of ferromanganese virtually all of the iron and phosphorus contained in the crude ore enters the resultant alloy. As usability of the ore depends upon the ratio of manganese to iron, ores high in iron can not be used in making ferro. The usual specification of the trade is that manganese ore must contain in excess of 47 per cent Mn.

Spiegeleisen is an alloy of iron, manganese and carbon, in which iron greatly predominates. The usual specifications are:

	<u>Per cent</u>
Manganese .....	18 - 22
Iron .....	70 - 80
Silicon .....	1
Carbon .....	5 - 6
Phosphorus.....	.15
Sulphur .....	less than .05

These two alloys, ferromanganese and spiegeleisen, are used in the Bessemer and open-hearth processes for acid and basic steel. Invariably, they are added near the end of the process, and are charged directly into the furnace, or added to the ladle, or (under the English practice) placed in the launder through which the molten metal runs on being tapped from the furnace into the casting ladle, or are actually placed in the casting ladle itself.

The chemical properties of manganese, which put it in a class by itself in the manufacture of steel, are as follows: Preventing over-oxidation of the steel by eliminating the oxygen in the bath (deoxidation); eliminating of sulphur from the bath (desulphurization); retarding the formation of blowholes; rendering the slag fluid; adding the requisite amount of manganese desired in the finished steel; and recarbonizing the bath.



Silicomanganese and silicospiegel replace ferromanganese and spiegeleisen in fulfilling the trade demands for certain grades of steel. The usual requirements, as to analysis, for these two alloys are:

Silicomanganese		Per cent
Manganese	.....	55 - 70
Iron	.....	20 - 5
Silicon	..... about	25
Carbon	.....	.35

Silicospiegel		
Manganese	.....	20 - 50
Iron	.....	67 - 43
Silicon	.....	4 - 10
Carbon	.....	1.5 - 3.5

Manganese steel. - The percentage of manganese in manganese steel ranges from 12 to 40 per cent. These variations are due to the wide differences in the properties imparted to steel by slight changes of manganese content. Manganese steels are hard without being brittle, and are malleable although difficult to machine. Two classes of articles are manufactured from these steels: (1) Those that must offer great resistance to abrasion, either by friction against smooth, hard surfaces, or against hard, brittle and angular materials; and (2) those that must resist strains due to shock accompanying abrasion. Articles now commonly made of manganese steel are: Gears, pinions, sprockets, chains, dies, liners, wearing plates, rolls and rollers, railroad frogs and switches, and the crushing faces and digging parts of crushing and pulverizing machinery, such as plates, dies, rollers, and stamp-mill shoes. For making some of these articles manganese steel is practically the only alloy available, but for making others it is no more desirable than some other alloys, such as those of chromium, vanadium and tungsten, with which it must compete at current prices. 2/

Ferruginous manganese and mangiferous iron ores are used mainly in the manufacture of low-grade manganese pig. Lesser amounts are used in the direct manufacture of such products as mangiferous cast iron, suitable for the manufacture of car wheels. Because of their desulphurizing properties these ores are used in the manufacture of pig iron.

#### Oxidizers

The value of manganese ores when used as an oxidizer does not depend upon the content of manganese, but upon the available oxygen. Pyrolusite is the only common mineral of manganese containing a large amount of manganese dioxide. Polianite contains a larger proportion of available oxygen than pyrolusite, but because of its rarity it is not available in commerce. Pyrolusite, when absolutely pure, contains 36.8 per cent oxygen, of which 18.4 per cent is available.

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2/ An article by S. R. Stone, "Manganese steel for machinery parts," which gives in detail the uses to which manganese steel is applicable, was published in Iron Age, vol. 91, p. 141, 1913.



Several factors determine the suitability of pyrolusite for dry cells, such as the purity of the ore, and especially its content of iron, copper, nickel, cobalt, arsenic and other metals electro-negative to zinc. A desirable physical quality is porosity. Specifications usually call for an ore containing at least 80 per cent of  $MnO_2$ , (minimum available oxygen 14 per cent), less than 1 per cent of iron and less than 0.5 per cent of copper, nickel or cobalt. Ores with a much lower content of available oxygen may be usable if they are porous enough, as an example, the Philipsburg, (Montana) chemical ores. For use in the manufacture of chlorine, a chemical ore should be free from impurities that are soluble in the acid used for decomposing it. The presence of lime in the form of carbonate is objectionable. Ores that contain an excess of 2 per cent of this element are usually discarded. Ferrous compounds are objectionable. Phosphorus is harmless in ores used for the production of chlorine.

#### Decolorizing of Glass

A green color that turns to brown with age is imparted to glass when iron is present. Manganese dioxide removes this color; of necessity the ore used must be low in iron. The advantage of manganese dioxide over other oxidizing agents is that manganese gives a pink tinge to the glass; as this pink is complementary to the green imparted by iron, the two colors neutralize each other and a whiter glass is produced.

#### Drier of varnishes and paints

Manganese borate, a compound produced by the interaction of boric acid and a manganese salt, is used commercially as a paint drier. Ore required for this use must be of relatively high grade.

#### As a disinfectant

Salts of sodium or potassium when combined with manganates yield sodium or potassium permanganates. These salts are powerful disinfectants. They are germicidal because they are strong oxidizers. For many years in India a person suspected of carrying cholera germs was given potassium permanganate.

In the United States, a considerable tonnage of low-grade manganese ore containing a small amount of silver is utilized as a flux in smelting precious metals.

#### Substitutes

For the minor uses of manganese many substitutes are available, although no satisfactory substitute has been found for manganese dioxide in the manufacture of dry cells.

In the manufacture of steel, as has been stated, no satisfactory substitute for manganese is known. In Germany during the years 1917 and 1918, the shortage of manganese necessitated trial of many substitutes, such as aluminum in the form of silicon-aluminum alloys. Alumina does not act as a deoxidizer and often remains in the steel as slag inclusions. Aluminum has a greater

affinity for oxygen than manganese, but the oxidization of aluminum produces alumina which is relatively infusible. Aluminum can not eliminate sulphur or change the condition of sulphur as manganese can. A slight excess of aluminum tends to produce large pipes in the ingots. Silicon in the form of ferrosilicon probably has a greater affinity for oxygen than manganese has, but its use is attended by the following disadvantages: In slight excess it causes large pipes to form in ingots; the products of oxidation remain in the steel; it has no effect upon sulphur and no effect on the molecular disarrangement of the metal. Carbon-free titanium in the form of ferrotitanium is the most powerful deoxidizer known. Titanium does not alloy freely with iron and imparts to steel qualities that are not acceptable to the trade. Calcium, sodium, vanadium and boron alloys have been tried as deoxidizers, but homogeneous steel was not produced when they were used.

In 1925, 890,428 tons of high-grade manganese ore were utilized in the United States. It is estimated that of this amount 47,000 tons supplied the needs of all uses except the metallurgical. In other than metallurgical uses, 40,000 tons of chemical ore were used in the manufacture of dry cells; the rest, 7,000 tons satisfied the need of the chemical glass, brick, enamel, dye and pigment industries.

#### Consumption and Production

The world's consumption of manganese ores during 1925 was, in round numbers, 2,570,000 tons. Imports into the United States were 615,000 tons. Shipments of high-grade ore (35 per cent or more of manganese) from the mines in the United States, some 42 in all, amounted to 98,524 long tons. Thus domestic consumption amounted to 35 per cent of the world's production.

Percentage of world's production and consumption, 1925, by countries.

Country	Production	Consumption
England	0.10	10.84
Germany	0.14	7.88
France	0.12	18.31
United States	3.89	35.20
Russia	31.77	2.92
India	23.89	1.56
Brazil	12.14	- - -
Gold Coast	12.84	- - -
Cuba	0.92	- - -
Norway	- - -	7.78
	85.81	84.49

The table showing production and consumption indicates how interdependent the nations are for their supplies of manganese. Consumption, in this table, signifies the amount necessary to satisfy the trades of each country and does not include exports. If the manufacture of, we will say, ferromanganese, has been established in any country and if the major part of the ferromanganese made is exported to other countries, the industries of that country call for a certain amount of crude ore. The table above has been compiled to illustrate this point.







Production

Manganese ore produced in the principal countries, 1921-1925, in metric tons  
(Prepared by L. M. Jones, of the Bureau of Mines)

Country	Percent- age of man- ganese	1921	1922	1923	1924	1925
<b>North America:</b>						
Canada-----		62	66	-----	530	-----
Costa Rica-----	37-48	<sup>1</sup> 589	(2)	(2)	(2)	(2)
Cuba-----	35-48	2,930	4,351	19,636	25,310	23,758
Mexico-----	40+	-----	-----	2,246	(3)	(3)
Newfoundland-----		<sup>4</sup> 384	-----	-----	-----	-----
Panama <sup>2</sup> -----	50+	-----	(5)	406	-----	-----
United States-						
Continental (exclusive of fluxing ore)-----	35+	13,748	13,619	32,006	57,422	99,902
Porto Rico <sup>1</sup> -----	35+	(3)	(3)	2,799	4,698	4,260
<b>South America:</b>						
Brazil <sup>1</sup> -----	38-50	275,694	340,706	235,831	159,229	311,882
Chile-----	40-48	23	900	4,287	4,243	(3)
<b>Europe:</b>						
Austria-----		(7)	(7)	(7)	(7)	(7)
Czechoslovakia-----		43,541	23,557	42,043	79,133	(3)
France-----	30+	3,519	5,224	5,993	3,680	3,185
Germany-----	30+	3,385	5,532	10,245	3,554	(3)
Hungary-----	30	-----	-----	403	1,217	(3)
Italy-----	30-50	4,558	4,529	9,605	12,189	14,934
Portugal-----	38-70	353	239	(3)	(3)	(3)
Rumania-----	42	3,035	5,392	12,511	6,482	(3)
Russia-----	41-48	<sup>1</sup> 28,819	<sup>8</sup> 90,739	<sup>8</sup> 240,885	<sup>2</sup> 500,693	<sup>3</sup> 216,507
Spain-----	29+	20,093	25,455	28,615	20,840	36,072
Sweden-----		6,253	4,528	5,203	10,885	(3)
United Kingdom-----	30+	522	254	2,053	2,496	(3)
Yugoslavia-----		910	1,122	5,145	4,570	2,716
<b>Asia:</b>						
China <sup>1</sup> -----		25,627	19,230	27,572	38,538	43,260
Dutch East Indies-----	45-52	2,093	3,233	5,245	8,482	10,000
India-----	47-52	690,189	482,015	706,210	815,894	<sup>1</sup> 613,895
Japan-----	50+	3,881	4,440	5,474	7,535	(3)
<b>Africa:</b>						
Algeria <sup>1</sup> -----		1,893	-----	651	406	450
Egypt-----		55,065	104,143	132,384	150,194	(3)
Gold Coast-----	50+	7,511	67,174	<sup>1</sup> 141,875	<sup>1</sup> 259,441	<sup>1</sup> 330,000
Tunisia-----	42+	1,500	180	1,153	3,220	1,655
Union of South Africa-----	40-60	287	157	393	530	454
<b>Oceania:</b>						
Australia-						
New South Wales-----		3,571	2,436	2,597	4,457	1,183
Queensland-----		846	68	75	-----	-----
Victoria-----		10	152	-----	-----	-----
South Australia-----		1,622	649	171	321	-----
Western Australia <sup>1</sup> -----		16	18	22	20	-----
New Caledonia-----		4,200	1,083	64	-----	-----

<sup>1</sup> Exports.

<sup>2</sup> It is reported that no work has been done on the manganese deposits since 1920.

<sup>3</sup> Data not available.

<sup>4</sup> Exports for year ended June 30 of the year stated in heading of column.

<sup>5</sup> Imports into the United States. Figures for production and exports not available. Figures for 1923 represent manganese content of ore.

<sup>6</sup> Less than 1 ton.

<sup>7</sup> Estimated manganese content of manganiiferous iron ore produced was as follows:  
1921, 13,345 tons; 1922, 19,947 tons; 1923, 24,033 tons; 1924, 15,007 tons; 1925,  
21,387 tons.

<sup>8</sup> Figures for the operating year ended Sept. 30.



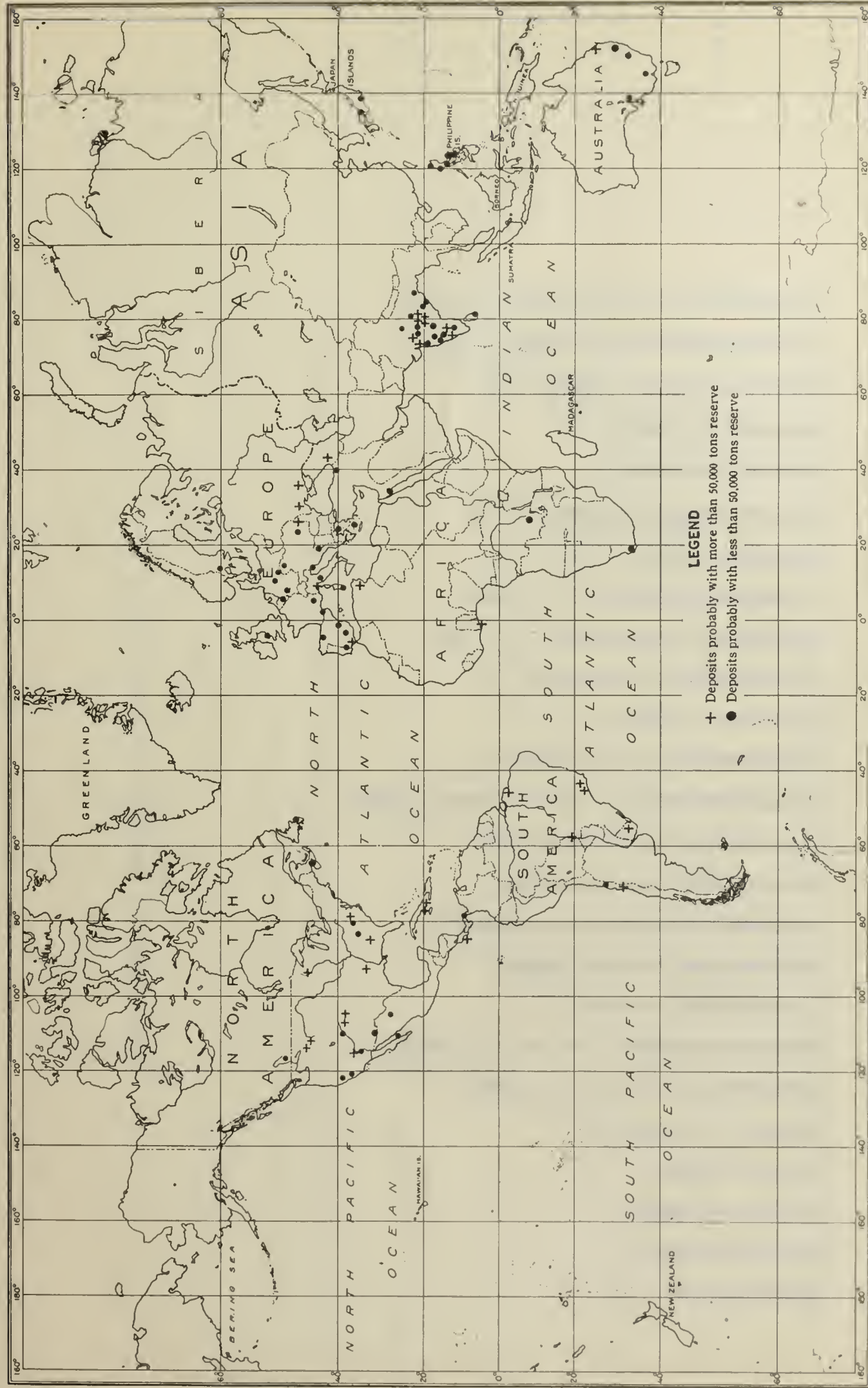


Fig. 1 -- GEOGRAPHICAL DISTRIBUTION OF THE PRINCIPAL MANGANESE DEPOSITS OF THE WORLD





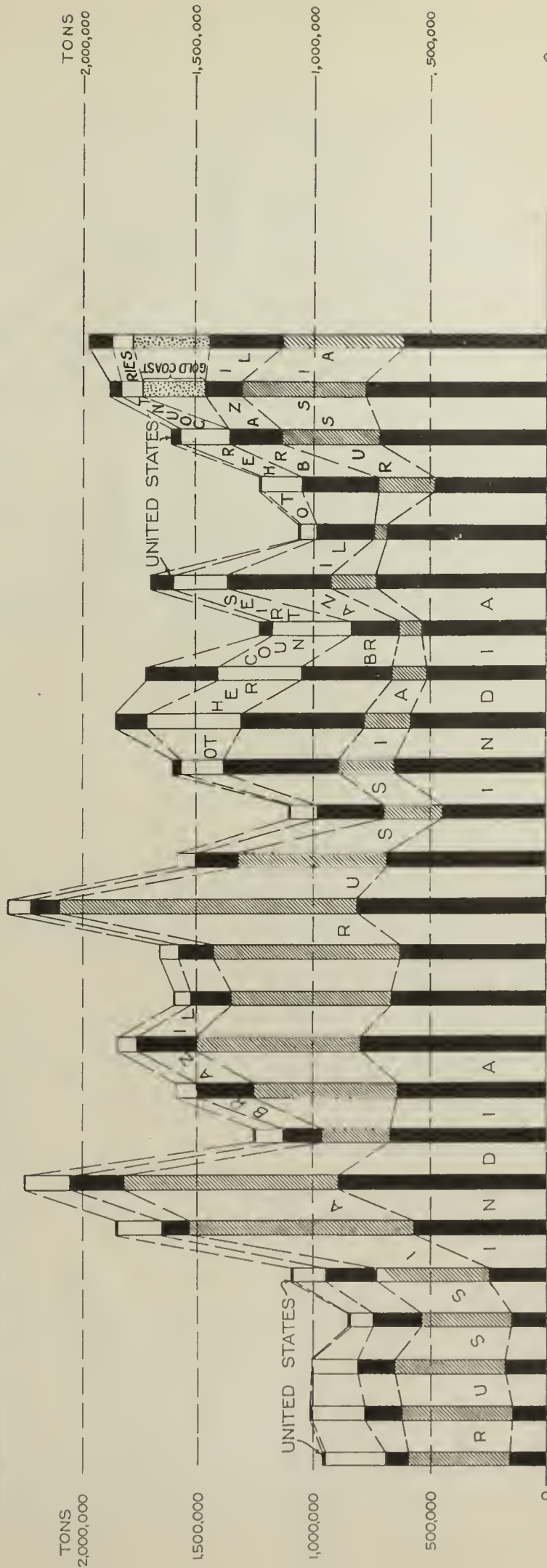
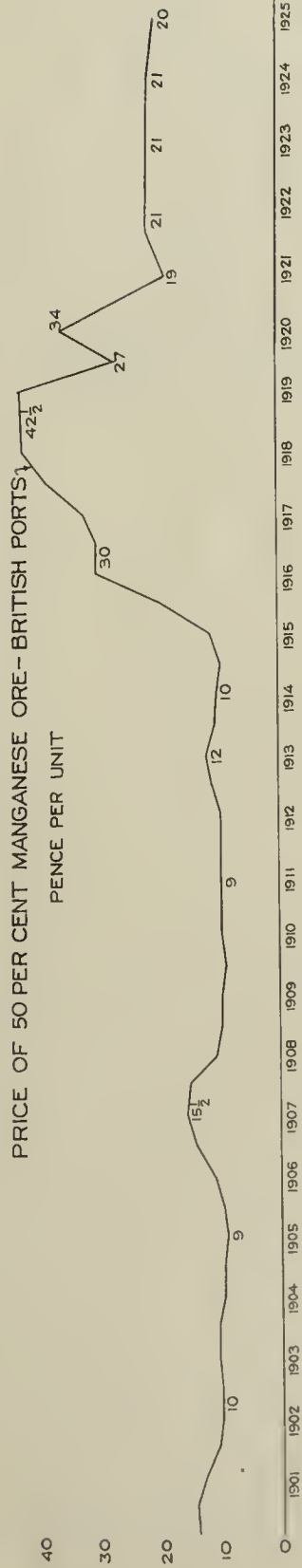


Fig.2- PRODUCTION OF MANGANESE ORE - INDIA, RUSSIA, BRAZIL, UNITED STATES AND REST OF WORLD 1901-1925





In the United States the production of manganese, except during a few years prior to the advent of the Bessemer and open-hearth processes for making steel, has never been able to satisfy the domestic demand. The occurrences of manganese in this country are, broadly speaking, well known, and if the past history of mining of this metal is taken to indicate the trend of the future, the United States does not possess a supply that can meet its demands. Unless methods are evolved for beneficiating low-grade manganiferous ores, this country must remain dependent upon foreign sources as long as manganese is required in the manufacture of steel. Mining of manganese in the United States began in 1832 at the Paddy Run mine, Frederick County, Virginia, and during the first few years of its operation some 5,000 tons of high-grade ore were shipped to England. During the years 1885 to 1890 inclusive, the Crimora mine of Augusta County, Virginia, supplied a large part of the needs of the Carnegie Steel Company. Since 1890 the domestic production has ranged from a fraction of 1 per cent of the domestic needs to some 32 per cent during the war years of 1917 and 1918. The ores produced during these years were mixed with high-grade imported ores in order to render them usable. Utilization of the domestic ores during that period was made possible only by modification of peace-time specifications. Except for the chemical ores produced in the Philipsburg district of Montana, the supply of high-grade metallurgical manganese ores in the United States is meager.

Manganese and manganimferous ore (exclusive of fluxing ore) shipped from mines in the  
United States in 1925, by States, in gross tons.

State	Ore containing 35 per cent or more of manganese			Ore containing 10 to 35 per cent of manganese			Ore containing 5 to 10 per cent of manganese		
	Number of shippers	Shipments	Value	Number of shippers	Shipments	Value	Number of shippers	Shipments	Value
<b>METALLURGICAL:</b>									
Alabama.....	2	938	\$12,544	5	298	\$ 3,087	-	-	-
Arizona.....	3	294	5,102	-	-	-	-	-	-
Arkansas.....	4	3,517	79,335	9	5,076	23,140	-	-	-
California.....	3	869	17,525	-	-	-	-	-	-
Colorado.....	1	743	5,127	5	7,352	26,565	-	-	-
Georgia.....	8	1,649	20,281	20	28,038	133,215	-	-	-
Massachusetts.....	1	(1)	(1)	1	(1)	(1)	5	7,349	\$ 23,397
Michigan.....	-	-	-	2	98,753	(1)	-	-	-
Minnesota.....	-	-	-	3	77,665	184,121	-	-	-
Montana.....	4	55,659	585,031	-	-	-	4	741,409	1,577,301
Nevada.....	2	850	(1)	1	6,659	(1)	-	-	-
New Mexico.....	2	1,588	(1)	2	40,848	153,251	-	-	-
North Carolina...	2	(1)	(1)	-	-	-	-	-	-
Tennessee.....	1	352	8,800	1	(1)	(1)	-	-	-
Utah.....	1	50	(1)	3	666	5,754	1	496	(1)
Virginia.....	3	1,499	22,981	1	1,800	(1)	-	-	-
Washington.....	1	8,113	(1)	-	-	-	-	-	-
Wisconsin.....	-	-	-	-	-	-	-	-	-
Undistributed....	-	52	198,073	-	97	386,183	1	404,014	(1)
	38	76,173	954,799	53	267,252	915,316	11	1,153,268	1,198,705
									2,799,403
<b>CHEMICAL:</b>									
Montana.....	3	20,529	825,970	-	-	-	-	-	-
Virginia.....	1	1,622	77,000	-	-	-	-	-	-
	4	22,151	902,970	-	-	-	-	-	-

1/ Included under undistributed.

Manganese and manganiiferous ore (exclusive of fluxing ore) shipped from mines in the United States in 1924, by States, in gross tons.

State	Ore containing 35 per cent or more of manganese			Ore containing 10 to 35 per cent of manganese			Ore containing 5 to 10 per cent of manganese		
	Number of shippers	Shipments	Value	Number of shippers	Shipments	Value	Number of shippers	Shipments	Value
<b>METALLURGICAL:</b>									
Alabama.....	3	1,242	\$24,954	9	611	\$ 6,722	-	-	-
Arizona.....	1	42	798	-	-	-	-	-	-
Arkansas.....	6	3,400	60,350	6	7,991	37,170	-	-	-
California.....	2	850	(1)	-	-	-	-	-	-
Colorado.....	2	5,338	48,042	7	27,058	109,289	-	-	-
Georgia.....	8	1,093	18,304	19	14,182	73,684	1	3,891	(1)
Michigan.....	-	-	-	1	50,556	157,184	6	6,353	\$ 16,558
Minnesota.....	-	-	-	4	159,915	439,132	1	39,939	(1)
Montana.....	-	-	-	-	-	-	3	361,527	970,351
Nevada.....	3	11,933	123,456	-	-	-	-	-	-
New Mexico.....	3	1,310	13,579	3	2,591	15,997	-	-	-
New Tennessee.....	2	775	(1)	2	23,246	(1)	-	-	-
Tennessee.....	2	455	11,611	-	-	-	-	-	-
Utah.....	-	-	-	2	116	1,010	-	-	-
Virginia.....	2	440	(1)	2	204	(1)	-	-	-
Washington.....	1	5,000	100,000	-	-	-	-	-	-
Wisconsin.....	-	-	-	-	-	-	-	-	-
Undistributed.....	-	-	39,920	-	-	-	1	175,316	606,593
	35	31,878	441,014	55	286,470	89,202	-	-	120,441
						929,390	12	587,026	1,713,943
<b>CHEMICAL:</b>									
Montana.....	3	23,512	816,463	-	-	-	-	-	-
Virginia.....	1	1,125	50,000	-	-	-	-	-	-
	4	24,637	866,463	-	-	-	-	-	-

1/ Included under "Undistributed."



## Sources

The major sources of the world may be divided into three groups based upon potential production: (1) Russia, India, Brazil, Gold Coast; (2) Czechoslovakia, Chile, Cuba, Spain, China; and (3) those countries in which the known deposits are of minor importance, including the Sinai Peninsula, 3/ the United States, Germany, France, England, Canada, Panama, South Africa, Japan, Costa Rica, Mexico, Newfoundland, Austria, Italy, Portugal, Rumania, Sweden, Yugoslavia, Dutch East Indies, Algeria, Morocco (French), Tunisia, New Caledonia, and Australia.

The world at present depends upon four great sources for its manganese: Russia, India, Brazil and the Gold Coast. In 1925, the world's production was approximately 2,570,000 tons, of which Russia produced 32 per cent; India 24 per cent; Brazil 12 per cent and the Gold Coast 13 per cent.

### Russia

Manganese occurs in many places in Russia. The developed deposits consist of those of Nikopol in southeastern Russia, north of the Caucasus, and the Tchiaturi deposit in the Province of Kutais, Republic of Georgia, south of the Caucasus. The Nikopol deposits have been estimated to contain upwards of 10,000,000 tons of commercial high-grade ore. Prior to 1924 they were of little importance to the outside world, but for many years they had furnished the domestic needs of Russia and small shipments had been made by rail to Germany. During the latter part of 1924 these deposits were leased to German citizens under a concession granted by the Soviet Government. The concessionaires claim to have been able to supply the needs of Russia, the major part of the consumption of Germany, and to have on hand in 1925 upwards of 270,000 tons of high-grade ore for export.

The Tchiaturi deposit may be classed as the largest single deposit now known; it covers some 22 square miles and estimates of the total commercial ore range from 44,000,000 to 200,000,000 tons. The deposit lies 110 miles from tidewater, and the principal port of shipment is Poti on the Black Sea, where an artificial harbor has been constructed. As the bed is near the surface of a plateau, it is exposed along the sides of six valleys cut by the Kvirila River and its branches. As the valleys are 800 to 1,000 feet and the bed lies 500 to 700 feet above their floors the opening of mines is much facilitated. The thickness of the seam or bed, where exposed, ranges from 3 to 13 feet. Two grades of ore are produced, washed and unwashed, or concentrated and crude. The manganese content of the crude ore is 40 to 52 per cent; that of the washed ore produced averages more than 50 per cent. The ore consists mainly of pyrolusite associated with minor proportions of psilomelane and wad. For many years, this deposit was the world's chief source of chemical ore. As the ratio of iron to manganese is low, the ore is very desirable for the manufacture of ferromanganese, a fact that offsets in part the fineness of the ore produced. For several years before the World War the Tchiaturi deposit led the world in shipments of manganese. In 1900 it yielded 44 per cent, and in 1913, 41 per cent of the world's total production. Since the World War, except in 1925, India has led.

---

3/ A large producer of ferruginous manganese ore.

Because of quality, quantity, accessibility, and cheapness of mining the Tchiaturi deposit will be for many years one of the controlling factors in the world's manganese situation.

From July, 1925, to December 31, 1925, the exports of manganese from the Tchiaturi deposit were as follows:

Destination	Metallurgical	Chemical	Total
United States.....	120,070	- - -	120,070
Germany.....	5,856	2,264	8,120
France.....	1,988	- - -	1,988
Italy.....	13,474	15	13,489
England.....	8,023	104	8,127
	149,411	2,383	151,794

### India

India has large reserves of manganese. The number of known deposits exceeds several hundred. At present some 50 to 75 deposits are contributing to an annual output of roughly 660,000 tons. Eighty per cent of this production comes from the Central Provinces. The largest deposit in that district is a bed 45 to 50 feet thick which has been explored in length for a mile and three-quarters, and has yielded more than 1,300,000 tons of 50 per cent ore. The Geological Survey of India estimates that an annual production of 600,000 tons may be maintained for upwards of 40 years. Psilomelane is the chief mineral, but the ore contains small proportions of pyrolusite and other manganese minerals. The larger part of the Indian ores is mined by the open case or quarrying method. As the ores won by this method are exhausted underground mining will have to be undertaken. By far the largest proportion of the reserve is in deposits that are supposed to have been formed by the metamorphism of a series of sediments. L. L. Fermor of the Indian Survey estimates that the depths of these deposits exceed 500 feet. Because of its higher content of iron, Indian ore is not as desirable as Russian ore for making ferromanganese, but this defect is partly offset by excellent structure and a low content of phosphorus. The cost of production at the mine is comparable to that in Russia. On account of the geographical position of the developed mines, transportation costs are higher than for the Caucasus deposits. In 1925 the quantity and destination of the exports were as follows:

To	Tons
United Kingdom . . . . .	180,472
Germany. . . . .	30,258
Belgium. . . . .	175,334
France . . . . .	150,585
Italy. . . . .	16,875
Japan. . . . .	- - - -
United States. . . . .	49,164
Other Countries. . . . .	1,510
	604,193



## Brazil

The principal source of manganese in Brazil is the Lafayette district some 300 miles north and west of Rio Janeiro. The largest developed group of deposits there is known as the Morro de Mina, and is estimated to contain upwards of 9,000,000 tons. Many undeveloped deposits containing large amounts of high-grade ore are at present inaccessible. There seems little question that some day this area will supply a considerable part of the manganese the world will then require. Under present conditions and needs the reserves of the developed deposits have been estimated to contain more than 15,000,000 tons of commercial ore. The ore carries 40 to 49 per cent of manganese. A high content of silica renders Brazilian ore less satisfactory than either Russian or Indian ores for the manufacture of ferromanganese. Of late the manganese content of the ore has decreased and the proportions of silica and aluminum have correspondingly increased. In the State of Bahia the deposits are of the residual type and consist largely of nodules of pyrolusite and psilomelane. In the Lafayette District the ore is massive and is the result of the oxidation of manganese carbonates and silicates. Mining costs are higher than in India or Russia. For 1925, the quantity and destination of the exports were as follows:

To	Tons
Belgium . . . . .	10,185
United States . . . . .	240,537
Great Britain . . . . .	6,000
Holland . . . . .	34,383
All others <u>1/</u> . . . . .	20,777
	<u>311,882</u>

1/ Includes shipments from Bahia, for which the countries of destination are not available.

## Gold Coast

The Gold Coast is known to contain several deposits of manganese.

Except for the deposits found in what is known as the Dagwin Concessions, the deposits so far discovered lie some 300 miles from tidewater. The only developed property is the Dagwin mine, in the Dagwin Concessions, 35 miles from tidewater, on the Sekondi Railroad. This deposit, which was discovered in 1914, is estimated to contain upwards of 10,000,000 tons of ore in place and 2,000,000 to 3,000,000 tons of detrital ore. The ore in place has been developed to a depth of 240 feet below the outcrop; its grade and quality are comparable to those of Georgian washed ore. Shipments containing 50 to 52 per cent of manganese, 2 to 4 per cent of iron, 3 to 7 per cent of silica and 0.1 to 0.12 per cent of phosphorus have been made. The principal minerals are psilomelane, pyrolusite and magnetite. Mining costs are comparable to those at India or the Caucasus deposits. Further development will no doubt greatly increase the reserves and the deposit will probably be productive for many years. Shipments in 1925 approximated 330,000 tons and those in 1926 were expected to be larger. Data on the destination of shipment are not available. A considerable quantity goes to Norway where it is manufactured into ferro and is then shipped to England and the United States. Crude ore is shipped to Canada and the United States also.



### Summary

The United States, as the largest producer of steel, utilizes approximately 35 per cent of the world's annual output of high-grade manganese ores, but in 1925, its contribution to that output was only 4 per cent. Because of the political and commercial control of the great sources of manganese, the domestic consumer has in the past been able to purchase his requirements in what may be termed a buyer's market. The Russian deposits are politically and commercially controlled by the Soviet Socialist Republic of Georgia; the Indian deposits, politically and commercially by Great Britain; those of the Gold Coast, politically by Great Britain and commercially by citizens of the United States; those of Brazil, politically by the Brazilian Government and commercially, in the main, by citizens of the United States.

Before the World War, the keen competition between the three great sources then available, a combination of any two of which was able to supply the world's demand, maintained a price that was only slightly in excess of the actual cost of production. Since the War, with the development of the Gold Coast and the potential development of Southwest Africa, the competition in the world's market has been greatly increased. During the next few years, the flow of manganese from its sources will probably vary from time to time with modifications of commercial barriers and with political developments.



Manganese production through 1925 and reserves in the United States, in gross tons.

(The production figures in this table do not agree with the figures which appear in the standard tables of domestic production in the Mineral Resources chapters on manganese. The figures in the tables in the chapters are the totals reported to the U. S. Geological Survey since its organization, and earlier Federal agencies, and are probably minima for each State, whereas the totals in this table aim to be maxima where the records are obscure.)

State	Total production through 1925 (including fluxing ore and manganese zinc residuum).		Ore containing 5 to 35 per cent of manganese	Total number of deposits examined	Crude		Concentrate		Total		Recoverable manganese	
	Ore containing 35 per cent or more of manganese	Ore containing 5 to 35 per cent of manganese			Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Alabama-----	3,615	2,668	12	-----	-----	2,800	7,800	2,800	7,800	1,300	3,500	
Arizona-----	45,385	38,020	118	59,200	79,200	15,000	20,000	74,200	99,200	33,400	44,600	
Arkansas:												
Batesville-----	95,637	92,322	203	160,000	210,000	112,000	152,000	272,000	362,000	126,500	168,300	
Western-----	334	-----	49	600	1,000	-----	-----	600	1,000	300	500	
Total Arkansas-----	95,971	92,322	252	160,600	211,000	112,000	152,000	272,600	363,000	126,800	168,800	
California-----	78,654	359	355	97,700	157,700	-----	-----	97,700	157,700	39,100	63,100	
Colorado-----	28,799	3,088,078	92	141,600	241,600	-----	-----	141,600	241,600	49,600	84,600	
Georgia-----	114,442	147,165	109	-----	-----	80,800	195,800	80,800	195,800	33,900	82,200	
Michigan-----	137	(1)	5	-----	-----	-----	-----	-----	-----	-----	-----	
Minnesota-----	-----	5,140,800	23	-----	-----	-----	-----	-----	-----	-----	-----	
Montana:												
Butte, carbonate-----	185,369	-----	2	70,500	385,500	-----	-----	70,500	385,500	25,400	138,800	
Butte, low-grade-----	-----	22,253	38	-----	-----	73,200	123,200	73,200	123,200	30,700	51,700	
Philipsburg-----	423,000	10,044	23	186,300	231,300	70,000	140,000	256,300	371,300	102,500	148,500	
Other-----	428	1,579	21	400	400	-----	-----	400	400	150	150	
Total Montana-----	608,797	33,876	84	257,200	617,200	143,200	263,200	400,400	880,400	158,750	339,150	
Nevada-----	27,059	461,525	58	17,800	27,800	-----	-----	17,800	27,800	7,100	11,100	
New Jersey-----	235	3,259,212	4	-----	-----	-----	-----	-----	-----	-----	-----	
New Mexico-----	11,422	237,283	61	11,000	17,500	-----	-----	11,000	17,500	4,400	7,000	
Oregon-----	500	-----	41	1,000	2,000	27,000	50,000	28,000	52,000	11,200	20,800	
Tennessee-----	14,649	2,182	134	1,900	3,900	37,000	55,000	38,900	58,900	14,800	22,400	



Manganese production through 1925 and reserves in the United States, in gross tons (Continued).

Utah-----	14,522	1,414	53	9,000	12,000	-----	-----	9,000	12,000	4,050	5,400
Virginia-----	380,431	43,795	255	-----	-----	-----	293,500	293,500	993,500	123,300	417,300
Washington-----	13,288	393	16	16,900	41,900	-----	-----	16,900	41,900	8,500	21,000
Wisconsin-----	(1)	(1)	1	-----	-----	-----	-----	-----	-----	-----	-----
Other States 2 -----	6,256	6,598	172	8,000	10,000	-----	-----	8,000	10,000	3,360	4,200
Grand total-----	1,444,162	12,564,690	1,850	781,900	1,421,800	711,300	1,737,300	1,493,200	3,159,100	619,560	1,295,150
Chemical ore-----	1,444,162	12,564,690	1,850	186,300	231,300	-----	-----	186,300	231,300	74,500	92,500
Metallurgical ore-----				595,600	1,190,500	711,300	1,737,300	1,306,900	2,927,800	545,060	1,202,650

1 Figures of total production for Michigan and Wisconsin are not available. Available early figures cover the Lake Superior region.

2 "Other States" under high-grade production are Massachusetts, Missouri, North Carolina, Oklahoma, Pennsylvania, South Carolina, South Dakota, Texas, Vermont, West Virginia, and Wyoming; under low-grade production are Mississippi, North Carolina, South Carolina, Texas, and Vermont; under reserves of ferro grade are Idaho, Maryland, New Jersey, North Carolina, Oklahoma, Texas, and Wyoming; and under reserves of spiegel and pig iron grade are Idaho, Mississippi, and Oklahoma.

Manganese production through 1925 and reserves in the United States, in gross tons - Continued.

Indicated total reasonably possible reserves of ore of spiegel and pig grade (5 to 35 per cent of manganese), at an index price of \$50 a ton for ferro grade ores, by States.										
State	Crude		Concentrate		Total		Recoverable manganese for spiegeleisen		Recoverable manganese for manganese pig iron	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Alabama-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arizona-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arkansas:										
Batesville-----	32,200	56,200	130,000	170,000	162,200	226,200	32,400	45,200	-----	-----
Western-----	32,200	56,200	130,000	170,000	162,200	226,200	32,400	45,200	-----	-----
Total Arkansas-----	32,200	56,200	130,000	170,000	162,200	226,200	32,400	45,200	-----	-----
California-----	50,000	75,000	-----	-----	50,000	75,000	-----	-----	2,500	3,750
Colorado-----	1,403,200	2,403,200	-----	-----	1,403,200	2,403,200	350,800	600,800	-----	-----
Georgia-----	-----	-----	27,800	112,800	27,800	112,800	5,600	22,600	-----	-----
Michigan-----	606,300	1,126,300	-----	-----	606,300	1,126,300	3,500	7,200	41,400	76,100
Minnesota-----	23,353,000	32,353,000	-----	-----	23,353,000	32,353,000	841,200	1,246,300	1,844,400	2,474,300
Montana:										
Butte, carbonate-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Butte, low-grade-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Philipsburg-----	-----	-----	40,000	65,000	40,000	65,000	12,000	19,500	-----	-----
Other-----	1,600	3,600	-----	-----	1,600	3,600	300	600	-----	-----
Total Montana-----	1,600	3,600	40,000	65,000	41,600	68,600	12,300	20,100	-----	-----
Nevada-----	129,300	229,300	-----	-----	129,300	229,300	15,500	27,500	-----	-----
New Jersey-----	-----	-----	4,518,500	5,518,500	4,518,500	5,518,500	542,200	662,200	-----	-----
New Mexico-----	391,800	891,800	-----	-----	391,800	891,800	62,700	142,700	-----	-----
Oregon-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee-----	-----	-----	5,000	10,000	5,000	10,000	1,250	2,500	-----	-----







Manganese production and costs during war period (1917-18)

(Compiled in 1923 by J. W. Furness, of the Bureau of Mines)

State	Production (gross tons), exclusive of fluxing ore			Data based on War Minerals Relief Commission claims										Pro-duction cost per ton
	Num-ber of depos-itors, pro-ducers, and ship-pers	35+ per cent	5 to 35 per cent	Num-ber of depos-its pro-duc-ing less than 50 tons	Num-ber of claims filed	Production		Claimant's total investment	Num-ber of awards made	Number of tons pro-duced	Total amount of awards	Cost per ton	Amount received per ton	Capital in-vested per ton
						35+ per cent	5 to 35 per cent							
Alabama-----	7	973	443	4	4	12,496	-----	\$176,506.79	1	2,496	\$74,909.61	\$57.00	\$27.30	\$71.00
Arkansas-----	36	17,871	18,273	15	99	10,176	-----	1,059,499.46	50	3,142	148,133.63	68.00	32.10	335.00
Georgia-----	29	10,293	24,057	5	27	6,449	-----	562,404.98	20	5,829	235,450.60	78.00	38.00	96.80
Tennessee-----	24	6,158	2,441	6	39	4,896	-----	642,391.33	15	2,186	54,953.51	51.00	24.60	293.00
Virginia-----	44	23,288	47,172	8	40	12,864	-----	3,066,733.54	25	9,871	343,222.62	58.00	24.20	305.20
Arizona-----	42	32,414	4,026	10	26	10,729	-----	342,362.43	8	1,892	69,368.94	56.00	20.40	180.00
Nevada-----	29	23,322	258	12	25	13,053	-----	223,051.68	3	598	5,841.62	32.00	22.80	374.00
New Mexico-----	23	5,729	48,732	6	18	1,577	22,571	332,756.63	11	21,183	55,270.93	52.00	23.00	130.00
Utah-----	14	9,295	36	4	16	9,677	-----	358,742.19	13	6,759	39,019.88	24.00	20.50	53.00
Colorado-----	35	4,881	203,422	3	20	500	39,006	330,434.31	12	320,231	56,214.79	12.00	9.80	16.70
Montana-----	29	261,041	1,568	16	48	50,216	-----	1,459,949.35	35	23,102	81,408.20	18.00	15.80	62.20
California-----	81	38,263	220	29	88	19,502	-----	721,728.91	34	11,448	156,757.95	31.00	18.40	62.00
Minnesota-----	16	-----	1,311,859	1	13	-----	204,905	2,317,119.65	12	447,653	1,135,560.03	30.00	5.40	48.50
New Jersey-----	1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
United States-----	2420	6435,220	71,739,123	8120	461	142,135	266,482	12,197,742.25	259	156,390	2,516,111.66	-----	-----	-----

1 This tonnage includes a portion from Georgia and North Carolina.

2 Also 20,000 tons of 5 to 35 per cent.

3 5 to 35 per cent.

4 5 to 20 per cent.

5 Includes 10 shippers from States named in footnotes 6 and 7.

6 Includes 1,692 tons from New Jersey, North Carolina, Oregon, South Carolina, South Dakota, Texas, and Wyoming.

7 Includes 76,586 tons from Michigan, North Carolina, South Carolina, Texas, and Wyoming.

8 Includes 1 shipper from South Dakota.





A study of the table showing domestic production and reserves, also table showing production and cost of production during the War period, indicates the position of the domestic production in reference to consumption. In addition to the reserves shown on the table above mentioned, there are large but unknown tonnages of material containing 20 per cent metallic manganese situated in the Butte District, Montana, and the Olympic Mountain District of Washington. In the Butte District, dikes occur composed largely of a mixture of rhodochrosite and rhodonite. In the Olympic Mountains the silicate of manganese, bementite, mixed with gangue material is found over a large area indicating that the reserves may be measured in hundreds of thousands of tons. The beneficiation of these ores, as well as the rendering of the manganese contained in the mangani-ferous and ferruginous manganese ores of this country constitute the only source from which domestic manganese may be produced in sufficient quantities to materially meet trade demand.

### Tariffs

Broadly speaking, foreign countries admit manganese free of duty. The royalty charged the concessionaires by the Soviet Government of Russia may be considered as an export duty. In India the export duty is indirect; it takes the form of a royalty leviable on the base metal and is 2.5 per cent on the sales value at the pit mouth or on the surface of the dressed ore or metal convertible at the option of the local government to an equivalent charge per ton to be fixed annually for a term. The Gold Coast Government collects a port duty of 2 shillings per ton. The Brazilian Government imposes an export tax of \$2.70 per ton on high-grade ore and in addition the provinces levy a tax which brings the total export tax up to an average of \$5.00 per ton. In the United States, prior to September 1922, there were no enactments that applied to either the domestic production or the importation of manganese ore. Under the enactment of 1922, a duty of 1 cent per pound on the metallic content when the tenor of the ore exceeds 30 per cent was imposed (Cuba production excepted). On ferromanganese a duty of 1-7/8 cents was imposed upon the metallic manganese content. As an example, the duty on a 50 per cent manganese ore (1120 pounds of manganese, at 1 cent a pound) would be \$11.20. Ferromanganese calls for 80 per cent metallic manganese, or 1,792 pounds; this multiplied by 1-7/8 cents makes a total duty of \$33.60.

### Marketing

Ores of manganese are classified according to their manganese content, a fact that helps to indicate the uses to which they may be put. Materials containing more than 35 per cent of manganese are known as manganese ores; materials containing 10 to 35 per cent manganese are known as ferruginous manganese ores; and materials containing 5 to 10 per cent manganese are known as mangani-ferous iron ores. Chemical ores are an exception to what has been said, and their value is based upon their content of available oxygen.

Manganese ores are valued on the basis of so much for each unit (1 per cent) of metallic manganese contained, and with minor exceptions the unit of weight for all merchantable ore is the long ton of 2,240 pounds. Consequently, in the long ton a unit is 22.4 pounds, and in a short ton is 20 pounds. Ferruginous manganese ore and mangani-ferous iron ore may be handled on the unit basis, but as a rule the mangani-ferous iron ores are sold on the metallic content, that is, iron plus manganese, based upon the current price of iron ore. Prices



for chemical ores are based upon a dioxide content of 80 per cent, with premium for higher, and penalties, for lower content. Prices for foreign manganese ores are quoted as follows: So much per unit of manganese, c.i.f. (cargo, insurance and freight paid) port of destination; f.o.b. (freight on board) mine or tide-water; or f.a.s. (freight aboard ship).

#### Selected References on Manganese

Fermor, L., India Geological Survey Memoirs, vol. 37-1-2-3, 37-4, 1909.  
Harder, E. C., Manganese deposits of United States: U. S. Geol. Survey, Bull. 427, 1910. Penrose, R. A. F., Manganese, Arkansas Geological Survey, Annual Report for 1910, vol. 1. Curtis, A. H., Manganese ores, Imperial Institute Monograph, 1919.

The following is a partial buyers' directory:

#### MANGANESE ALLOYS

The Ajax Metal Co., Philadelphia, Pa.  
American Boron Products Co., Reading, Pa.  
S. Birkenstein & Sons, Inc., 1054 W. North Ave., Chicago, Ill.  
Debevoise-Anderson Co., 114 Liberty St., N. Y.  
Everitt & Co., Ltd., 40 Chapel St., Liverpool, Eng.  
Federated Metals Corp., 233 Broadway, N. Y.  
C. W. Leavitt & Co., 30 Church St., N. Y.  
Metal & Thermit Corp., 120 Broadway, N. Y.  
More-Jones Brass & Metal Co., St. Louis, Mo.  
Niagara Falls Smelt. & Refg. Corp., Buffalo, N. Y.  
Ralph Metals Corp., 4601 Woolworth Bldg., N. Y.  
Frank Samuel & Co., Philadelphia, Pa.  
Walter-Wallingford & Co., Cincinnati, O.

#### MANGANESE ORE

The American Metal Co., Ltd., 61 Broadway, N. Y.  
A. C. Daft, Pittsburgh, Pa.  
Debevoise-Anderson Co., 114 Liberty St., N. Y.  
Everitt & Co., Ltd., 40 Chapel St., Liverpool, Eng.  
Chas. Gitlan, 35 Nassau St., N. Y.  
H. Hollesen, Inc., 17 Battery Place, N. Y.  
Int'l Minerals & Metals Corp., 61 Broadway, N. Y.  
C. W. Leavitt & Co., 30 Church St., N. Y.  
Metal & Thermit Corp., 120 Broadway, N. Y.  
Mitsui & Co., Ltd., 65 Broadway, N. Y.  
Park & Williams, Inc., Philadelphia, Pa.  
Clement K. Quinn & Co., Duluth, Minn.  
Ralph Metals Corp., 4601 Woolworth Bldg., N. Y.  
Frank Samuel & Co., Philadelphia, Pa.  
C. Tennant Sons & Co. of New York, 19 West 44th St., N. Y.  
Wah Chang Trading Corp., Woolworth Bldg., N. Y.  
Watson, Geach & Co., Inc., 56 Pine St., N. Y.

MANGANIFEROUS ORES

Debevoise-Anderson Co., 114 Liberty St., N. Y.  
Everitt & Co., Ltd., 40 Chapel St., Liverpool, Eng.  
H. Hollesen, Inc., 17 Battery Place, N. Y.  
Park & Williams, Inc., Philadelphia, Pa.  
Clement K. Quinn & Co., Duluth, Minn.  
Frank Samuel & Co., Philadelphia, Pa.





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Circular No. 6036  
May, 1927.

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

QUESTIONS AND ANSWERS ON BUREAU OF MINES  
APPROVALS OF ELECTRICAL EQUIPMENT 1

This circular has been prepared to answer the numerous questions asked as to how the Bureau of Mines carries on its work of inspection, testing and approval of electrical equipment for permissible use, and what its recommendations are for the promotion of safety in mines. Various references are made in this paper to Bureau of Mines publications. The Bureau of Mines prints a limited free edition of most of its publications. When the free editions are exhausted, copies may be obtained, at cost price, through the Superintendent of Documents, Government Printing Office, Washington, D. C.

1. Q.- What is the purpose and scope of the Bureau of Mines "schedules"?

A.- The purpose of the Bureau of Mines schedules is to establish certain minimum standards of safety for all equipment, used in and about mines, which may present hazards to the life and health of mine workers by reason of causing ignition of combustible and explosive substances in the mines. Approvals apply only to the specific types of equipment having the same construction in every detail as the ones inspected, tested and approved for permissibility by the Bureau.

2. Q.- What is the relation between the Bureau's work and the State Inspection Departments?

A.- Except on the United States public lands the Bureau has no jurisdiction over equipment and practices in mines, but merely approves such equipment as has met the permissibility requirements of its schedule. The State Inspection Departments are invested with authority to enforce such safety measures as are required by the laws of the State.

3. Q.- How may cooperation between the Bureau of Mines and the State Inspection Departments with respect to the Bureau's approval work, be accomplished?

1 - The answers given are as of April 1, 1927. As the number approvals, types of permissible equipment, and publications are constantly being added to, the answers should be revised from time to time from Bureau's published lists.

A.- Cooperation between the Bureau of Mines and the State Inspection Departments with respect to the Bureau's approval work may be accomplished by the tactful dissemination of information regarding the advantages of using permissible equipment. This may be carried on by distribution of literature, reading of papers at mining conferences, personal contact of field engineers with inspectors, etc.

4. Q.- What classes of mining equipment have been approved under the various schedules assigned to the Electrical Section?

A.- The following classes of equipment have been approved under these schedules:

- Electric cap lamps,
- Electric hand lamps,
- Electric trip lamps,
- Electric flash lights,
- Electric drills,
- Electric coal-cutting machines,
- Electric pumps,
- Electric loading machines,
- Electric air compressors,
- Electric rock-dusting machines,
- Electric room hoists,
- Electric storage-battery locomotives,
- Electric storage-battery power trucks,
- Electric single shot-blasting machines,
- Junction boxes,
- Flame safety lamps,
- Methane detectors.

5. Q.- How does the Bureau call the public's attention to its approval work?

A.- The Bureau calls the public's attention to its approval work by distribution of publications, by permissibility or approval plates attached to the equipments, and by recommendation of the use of permissible equipment by field engineers.

6. Q.- What publications having a general application to safety work have been issued by the Electrical Section?

A.- Miners Circular 5 and 29.

Technical Papers 4; 19; 58; 271; 306; and 402.

Serials 2211; 2224; 2398; 2365.

Information Circular 6005 and 6021.



7. Q.- What are the Bureau's safety requirements for equipment such as coal cutting outfits, coal-loading machines, electric pumps, hoists, air compressors, etc. under Schedule 2B?

A.- The general safety requirements for such equipment are as follows:

1. All parts, such as motors, controllers, resistances, fuses and switches, which may produce sparks or flashes as the result of normal operation must be inclosed in sealed or locked, explosion-proof compartments.

2. All parts, such as wiring, which do not produce sparks or flashes as a result of normal operation, but may do so as a result of accident, must be adequately protected. Detailed requirements are given in Schedule 2B, published by the Bureau of Mines.

8. Q.- What types of equipments have been approved under this schedule?

A.- The following types of equipments have been approved:

- 3 electric drills
- 12 electric shortwall coal-cutting machines
- 1 electric low vein coal-cutting machine
- 2 electric turret coal-cutting machines
- 1 electric shearing and drilling machine
- 1 electric cutting-shearing machine
- 7 electric coal-loading machines
- 3 electric air compressors
- 2 electric mine pumps
- 1 electric room hoist
- 2 electric rock-dusting machines

9. Q.- Where should permissible motor equipment be used?

A.- Permissible motor equipment should be used wherever an explosive atmosphere of mine gas or coal dust may occur.

10. Q.- Give five reasons why permissible electric equipment should be safer than the so-called flame-proof equipment that has not been subjected to the Bureau's inspection and test.

A.- (a) Permissible equipments must conform to drawings on file with the Bureau and their design may not be modified without consideration by the Bureau of the effect of such changes on safety. The so-called "flame-proof" machines may be modified at will.

(b) A permissible machine must receive a careful inspection by the Bureau and all compartments inclosing parts likely to produce sparks must have successfully passed rigid tests in explosive gaseous mixtures.



(c) Permissible machine compartments are subjected to actual tests to prove their mechanical strength, and in case of failure must be re-designed to meet schedule requirements.

(d) Permissible machine compartments are allowed no through openings into their interior. Such openings are common on unapproved equipment.

(e) Permissible machine compartments receive special attention with respect to entrance of wires, a point frequently overlooked in unapproved equipment.

11. Q.-- How may electricity be the direct cause of a coal-dust explosion?

A.-- Electricity may set off a coal-dust explosion by an arc or an electrically heated part in an explosive cloud of dust or of gas and dust.

12. Q.-- How does the Bureau take this into consideration in testing equipment for permissibility?

A.-- In a certain proportion of the tests in explosive atmospheres coal dust is introduced into the compartments under test.

13. Q.-- How can a field engineer identify permissible equipment?

A.-- A field engineer can identify permissible equipment by the U. S. Bureau of Mines' approval plate on the machine. Machines bearing no approval plates are not permissible, regardless of assertions to the contrary.

14. Q.-- What publications give information respecting this general class of permissible equipment?

A.-- Bulletins 78 and 258.

Schedule 2B.

Serials 2123, 2419, 2422, 2434, 2431.

Information Circular 6021.

15. Q.-- Has the Bureau approved a junction box for use at the end of trailing cables?

A.-- Yes.

16. Q.-- In what particular way does the use of permissible junction boxes increase safety in mines?

A.-- The use of permissible junction boxes permits the connection of trailing cables to the power supply with less hazard from electric shock and with less possibility of causing dangerous electric sparks or arcs.

17. Q.- What are the Bureau's requirements for miners' electric cap lamps?

A.- The three requirements are safety, practicability, and efficiency. Lamps are tested for liability of gas being ignited by the filament of a broken bulb, or by sparks from the battery. The battery is tested for strength, liability to spill electrolyte, and for discharge characteristics over a 12-hour period. Bulbs are tested for uniformity of life, candlepower, current consumption, and angle of light distribution. Cords of cap lamps are tested for mechanical strength. Detailed requirements are given in Schedule 6B, published by the Bureau of Mines.

18. Q.- What provisions are necessary to prevent the spillage of electrolyte from a portable mine lamp battery?

A.- Three general methods of preventing the spillage of electrolyte are being successfully used: 1. Ventilating tubes which allow the free exit of gas but which trap the electrolyte. 2. Vent valves which seal the cells during discharge when the battery is worn. 3. The use of solidified or "jelly" electrolyte with which there is no free liquid. For these non-spilling devices to be completely effective, it is necessary that the manufacturers' instructions concerning the charging and refilling of the batteries be closely followed.

19. Q.- What are two possible sources of danger from unapproved types of electric cap lamps?

A.- Two possible sources of danger from such electric cap lamps are sparks from short circuiting of battery and ignition of gas from the glowing filament in bulb.

20. Q.- How does the Bureau determine that these dangers are not present in the approved types of electric cap lamps?

A.- By subjecting the lamps to rigid tests as to mechanical strength, by requiring proper insulation, limited battery capacity, effectively locked battery casing and locked or sealed headpiece and a safety device which will prevent ignition of gas by the bulb filament if the bulb glass be broken.

21. Q.- What publications relate to permissible electric cap lamps?

A.- Bulletins 52 and 131.  
Schedule 6B.

22. Q.- What are the Bureau's general safety requirements for flame safety lamps?



A.- The general safety requirements are, that a lamp shall have double-gauzes or equivalent, be bonneted, have a magnetic lock, a good grade of glass and give an adequate light continuously for at least 12 hours.

23. Q.- Why is the Bureau opposed to the use of unbonneted flame safety lamps?

A.- The gauzes of unbonneted lamps are unprotected from high velocity air currents and are much more liable to damage.

24. Q.- Why does the Bureau advocate the use of magnetic lock lamps?

A.- A lamp equipped with a magnetic lock is less liable to be opened in the mine than lamps equipped with other types of locks. The Bureau of Mines' disaster records show that officials as well as miners should be required to use magnetic lock lamps.

25. Q.- How is a flame safety lamp used in making examination for methane?

A.- An examination for the presence of methane is made as follows: After ascertaining that the lamp has been properly filled and is in safe working condition, the place to be tested is entered, the flame turned down to "cap" or nonluminous flame, the lamp slowly raised by the bowl to the desired height and height of gas cap, if any observed. If methane is found, the lamp should be lowered slowly, removed from the gas, and normal flame restored.

26. Q.- What heights of "gas caps" will be obtained in various percentages of methane?

A.- The relative heights of gas caps obtained are different for different types of lamps and for different fuels in the same lamp. The following are the approximate heights of gas caps for the round wick Koehler permissible type lamp using a gasoline fuel of about 68°-70° Baume.

Per cent methane	Height of cap, (inches)
1	0.3
2	0.4
3	0.6
4	1.3
5	Tip of cap above glass and hidden by bonnet

27. Q.- What Bureau publications are recommended as bearing on the subject of flame safety lamps?

A.- Miners Circular 12  
Serial 2302  
Bulletin 227

28. Q.- What are the Bureau's safety requirements for methane detectors?

A.- The Bureau's general safety requirements for methane detectors are: They shall not be capable of igniting explosive mine atmospheres. They shall be portable, durable in construction, practical in operation and suitable for service conditions under-ground. Detailed requirements are given in Schedule 8B published by the Bureau of Mines.

29. Q.- What methane detectors have been approved by the Bureau?

A.- The Burrell indicating type detector and the Solf flame lamp type detector.

30. Q.- How is examination for methane made with the Burrell detector?

A.- The steps in the operation of the Burrell methane detector are as follows: Remove air from gas chamber by blowing into rubber tube; holding detector by handle in the gas mixture to be tested; allow the water to return to its level, sucking in sample of gas; shake detector for 1 minute; burn sample 2 minutes; shake detector 1 minute; read per cent gas on scale. (For detailed operation and care of detector see manufacturers' instructions.)

31. Q.- What publications have been issued in regard to methane detectors?

A.- Serial 2367 and Technical Paper 357.

32. Q.- Is the Bureau prepared to make tests of mine-type telephones if they are submitted?

A.- Yes, under the requirements of Schedule 9A.

33. Q.- Has the Bureau approved a mine-type telephone?

A.- No, however one company reports progress in developing a permissible type 'phone.

34. Q.- In what way is the use of an unapproved type of telephone dangerous in a gassy mine?

A.- The operation of the magnetos of mine telephones produces electric sparks sufficient to ignite an explosive gaseous mixture at the magneto itself, also at the place where the call is received, if the receiver is taken down during the ringing. In unapproved types these spark producing parts are not inclosed in explosion-proof compartments.



35. Q.- What are the Bureau's requirements for miscellaneous lamps, such as hand lamps, trip lamps, rescue lamps and lamps for use on mules and horses?

A.- The Bureau's safety requirements for these lamps are that each lamp shall be equipped with a safety device to prevent ignition of methane and air mixtures in case the bulb glass is broken, also that the capacity of the battery shall be such that sparking from it will not ignite the mixtures. In addition, each type of lamp shall be adequate, both electrically and mechanically, for the particular service for which it is intended.

36. Q.- What classes of miscellaneous lamps have been approved under the provisions of Schedule 10A?

A.- Hand, trip and inspection lamps, the latter being a form of rescue service lamp.

37. Q.- What particular hazard does the use of an unapproved type flash-lamp present?

A.- An unapproved flash-lamp is not equipped with a safety device. The hazard in the use of such a lamp is that breakage of the bulb glass in a gaseous place may allow ignition of the gas by the heated filament.

38. Q.- What are the Bureau's safety requirements for electric flash-lamps?

A.- The lamps shall be so designed that neither breakage of bulb glass nor any sparks from the battery will ignite an explosive mine atmosphere.

39. Q.- For what services are permissible electric flash lamps recommended?

A.- The permissible type flash lamp is suitable for mine rescue service and for mine roof inspection service in which case it would be used as a special lamp in connection with an electric cap lamp or flame safety lamp.

40. Q.- What are the Bureau's requirements for single-shot blasting units?

A.- Single-shot blasting units must be inclosed in mechanically strong cases and have efficient locks. The operating device of each unit shall be separate from the unit itself and shall be so constructed that it is automatically disconnected from the unit after each shot. Breaking of the firing circuit shall not cause a spark sufficient to ignite an explosive mixture.

41. Q.- What types of single-shot blasting units have been approved?

A.- Three storage-battery types; four magneto types, and one dry-cell type.



42. Q.- How does approved equipment differ from similar equipment which has not been approved?

A.- Unapproved equipment may not have the mechanical strength of approved equipment and may cause sparks of sufficient strength to ignite explosive mixtures when connections or wires are broken.

43. Q.- Approximately what current will fire an electric detonator?

A.- An electric detonator may be fired by a current flow of 0.4 to 0.5 ampere. Such a small current will not, however, fire all of a series of detonators. To insure firing all shots of a group, a firing current of 1.5 amperes through each detonator is recommended.

44. Q.- What precautions, relative to electricity, should be taken with electric detonators?

A.- Before taking electric detonators underground the free ends of the leg wires should be twisted together. The detonators should be personally carried in receptacles made of fireproof and electrically non-conducting material and should not be taken from the receptacles except for the process of charging the shot hole. The detonator leg wires should never be connected to leading wires until it is certain that the leading wires are not in contact with any electric source.

45. Q.- How should cars and boxes intended for containing explosives during transportation in a mine be constructed, especially where electricity or open lights may prevail?

A.- The body of the car or box should be made of wood with no exposed metal parts such as bolt heads, on the interior. The car or box should be made waterproof and have a tight sloping cover so as to shed water. There should be partitions of insulating material to separate the various explosive containers.

46. Q.- What Bureau of Mines publications relating to the safe handling of explosives or accessories with respect to electric current have been issued?

A.- Bulletins 80 and 240 and Serial No. 2528.

47. Q.- What are the Bureau's safety requirements for storage-battery locomotives and power trucks?

A.- The Bureau's general safety requirements for storage-battery locomotives and power trucks are that all electrical parts which may produce dangerous sparks shall be inclosed in locked or sealed explosion-proof compartments. All wiring between these compartments shall be adequately covered and protected. The battery must be well insulated and inclosed in a well ventilated box which is locked to prevent tampering with the battery terminals. Detailed requirements are given in Schedule 15, published by the Bureau of Mines.

48. Q.- Storage battery locomotives (haulage type) and power trucks are similar in appearance. What are the distinguishing characteristics of these types of equipments?

A.- The batteries and their general arrangement are often identical; but whereas the locomotive is equipped with large motors for heavy haulage service, the power truck either has only a small motor equipment for self propulsion or, if of the non-propelled type, has no motor at all. It then has to be moved from place to place by a locomotive. Power trucks are equipped with plugs and receptacles by means of which power from the battery may be obtained to operate other equipment, such as cutting machines. If locomotives are equipped with power plugs and receptacles, they are called combination locomotives and power trucks.

49. Q.- What types of locomotives and power trucks have been approved?

A.- 14 gathering locomotives  
1 haulage locomotive  
1 combination haulage and power truck  
2 power trucks, self-propelled type  
1 power truck, non-propelled type

50. Q.- Why has not the Bureau approved trolley type locomotives?

A.- Straight trolley type locomotives present a constant hazard from arcs between trolley wheels and wire, also between wheels and track.

51. Q.- Why has not the Bureau approved combination trolley and cable reel locomotives?

A.- When operating from the trolley, these locomotives present the same hazard as a straight trolley locomotive. Also the hazard from the trailing cable is believed greater than for mining machines. The relative hazard is debatable.

52. Q.- What Bureau publications have been issued relative to tests of storage battery locomotives?

A.- Technical Paper 264.  
Serials No. 2449, 2474, 2581, and 2601.  
Schedule 15.  
Bulletin 258.

53. Q.- What are five possible dangers incident to the use of open lights in coal mines?

A.- (a) Open lights may come in direct contact with a body of gas and cause an explosion.



(b) Open lights may come in direct contact with an explosive mixture of coal dust and air, or coal dust and gas, and cause an explosion.

(c) Open lights may come in contact with explosives carried into the mine for blasting purposes.

(d) Open lights may come in contact with any combustible material which is brought into the mine such as lubricants, clothing, timber, etc.

(e) Open lights may be left in a coal mine in such position as to ignite the coal bed itself and cause a mine fire.

54. Q.- Why are permissible electric outfits not generally designed for constant use in gaseous atmospheres?

A.- Safe mining practice provides that, whenever gas in dangerous quantities is encountered, operations shall cease at that point until the gas has been removed.

55. Q.- How, and under what conditions will the installation of circuit breakers on branch circuits tend to lessen fire hazards?

A.- Circuit breakers on branch circuits tend to prevent the overloading of those circuits; also tend to prevent mine fires from broken or misplaced feeder wires. These breakers should be of the non-automatic type which will require personal attention to reset them, and therefore probable inspection for the cause of the trouble.

56. Q.- What States have the best regulations covering electrical safety?

A.- Pennsylvania, Washington, and Utah; the last named probably has the best general safety regulations at present.

57. Q.- What safety measures should go hand in hand with the use of permissible apparatus?

A.- Frequent and intelligent inspection should be made to maintain all safety features on an apparatus at their initial efficiency. No deviations or changes of any part of the apparatus should be permitted. Users of apparatus should conform to cautions printed on approval plate, and any other precautions dictated by common sense, such as rock-dusting, adequate ventilation, etc.- Information Circular, Bureau of Mines, Department of Commerce.



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Circular No. 6037

May, 1927.

## INFORMATION CIRCULAR

## DEPARTMENT OF COMMERCE - BUREAU OF MINES

ONE HUNDRED AND ONE QUESTIONS ON ELECTRICAL INSPECTION  
IN AND ABOUT MINES.Introduction.

For a long time it has been generally accepted that the duties of the mine inspector were confined to the study of the proper conduct of mining processes and of adequate ventilation. However, with the rapid introduction of mechanical and electrical appliances to speed up production, the inspector of today is almost forced to be well versed in all branches of engineering if he wishes to cover thoroughly all phases relating to the safe operation of a mine or else he must delegate certain work to specialists in the line with which he is unfamiliar.

Companies operating a number of properties generally employ an electrical engineer or inspector who can look after the installation and operation of the electrical equipments from the standpoint of safety. With the smaller companies this is not always possible but that does not prevent their making an intelligent inspection of the electrical installation to determine whether it conforms with recognized safe practices. This paper has been prepared with a view of indicating the more important points that should be observed in making an electrical inspection. The questions which follow are based upon Bureau of Mines Technical Paper 402, "Safety Rules for Installing and Using Electrical Equipment in Coal Mines." In most cases the answer will be in the affirmative if the equipment has been properly installed and is correctly used, but for details and a right understanding on any question, reference should be made to the technical paper mentioned.

General Safety.

1. Is some one regularly in charge of the electrical equipment at the mine?
2. Is the person in charge fitted for this position by ability, training, and experience?
3. Is anyone allowed to work on or with electrical equipment before being instructed in the performance of his duties?
4. Is care taken to insure good mechanical construction and neat workmanship in all electrical installations?
5. Is an electrical plan map kept?

6. Does this map show all permanently installed electrical machinery and apparatus; feeder circuit, trolley circuits, lighting circuits, communication circuits?

7. Is the plan map revised at least once in six months to show new additions or any change in location of permanently installed equipment?

8. Are caution notices conspicuously posted to warn persons of the presence of live electrical circuits?

9. Are caution notices conspicuously posted to warn persons of the presence of live electrical apparatus?

10. Are prohibitory notices conspicuously posted to prevent manipulation of electrical apparatus by unauthorized persons?

11. Are instructions for the restoration of persons suffering from electric shock posted prominently at every surface and underground station and at the mine entrance?

12. Are all underground stations equipped with sand or approved fire extinguishers?

13. Are metallic frames of all stationary motors grounded?

14. Are power-transformer casings grounded?

15. Are instrument-transformer casings grounded?

16. Is the metallic framework of switchboards grounded?

17. Are metallic conduit circuits electrically continuous throughout their length?

18. Is each conduit circuit connected to a good and sufficient ground?

19. Are metallic-armored circuits electrically continuous throughout their length?

20. Is each metallic-armored circuit connected to a good and sufficient ground?

21. Are the sheathings of lead-sheathed conductors electrically continuous throughout their length?

22. Is each lead sheathing connected to a good and sufficient ground?

23. Are the frames of portable drill motors effectively grounded?



Installation of Trolley Circuits.

24. Are trolley circuits installed anywhere except on strictly intake air?
25. Are trolley circuits extended beyond last breakthrough?
26. Are trolley wires continuous on one side of the rail?
27. Is there track clearance on side of entry opposite trolley wire?
28. Are shelter holes on side of entry opposite trolley wire?
29. Insofar as feasible, is trolley wire at uniform height above rail?
30. Are sufficient hangers used to keep trolley from touching rock, coal, or timber at all times?
31. Is trolley wire guarded (at places where it is less than 6-1/2 ft. above rail) where men must pass under it?
32. Is trolley wire sectionalized at least every 2500 ft.?
33. Is each branch trolley circuit provided with a frog at the point where it leaves the main circuit?
34. Is each branch trolley circuit over 100 feet in length provided with a switch installed at or near the frog so that it can be disconnected from the main circuit?
35. Is mounting of switch so arranged that the switch cannot close by gravity?
36. Is provision made for locking sectionalizing switches in the open position.
37. Are trolley-circuit rail returns carefully bonded at every rail joint?
38. Are rail returns cross-bonded at intervals not exceeding 200 feet?
39. Are special bonds used to take circuit around openings in rail returns such as at switches and frogs?

Feeder Circuits.

40. Do any feeder circuits enter the mine through the shaft?
41. Are the feeder circuits entering the shaft properly supported?
42. Are the feeder circuits properly insulated by space or otherwise from timbers or the side of the shaft?

43. Are the feeder circuits in the shaft properly guarded from mechanical injury from falling material?

44. Can all inside feeder circuits be made "dead" by means of a switch or switches near the foot of the shaft?

45. Do any feeder circuits enter the mine through boreholes?

46. Are the feeder circuits entering through boreholes adequately supported?

47. Can all inside feeder circuits be made "dead" by means of a switch or switches near the foot of the borehole?

48. Are feeder circuits installed in entries supported on insulators?

49. Are a sufficient number of insulators used to prevent the circuit from touching rock, coal, or timber?

50. Are feeder circuits on the same side of the entries as the trolley wire?

51. Are feeder circuits permitted anywhere except on strictly intake air?

52. Are feeder circuits permitted in any sections of the mine not regularly inspected?

53. Are feeder circuits extended beyond the last open break through?

54. Are sectionalizing switches for feeder circuits provided at intervals not exceeding 2500 feet?

55. Are branch feeder circuits which extend over 100 ft. provided with switches at the points where they leave the main circuits?

56. Are sectionalizing switches so mounted that they can not close by gravity?

57. Is provision made for locking sectionalizing switches in the open position?

58. Are all splices in feeder circuits made electrically efficient by soldering?

59. Is the negative or return wire of grounded feeder circuits insulated and supported in the same manner as the positive or live wire?



Lighting Circuits

- 60. Are lighting circuits used?
- 61. Are lighting circuits installed on insulators?
- 62. Does the load on any lighting circuit exceed 1300 watts?
- 63. Are insulated sockets used?

Shot-Firing Circuits

- 64. Are permanent shot-firing circuits used?
- 65. Are temporary shot-firing circuits used?
- 66. Are rubber-covered conductors used for temporary shot-firing circuits?
- 67. Are permanent shot-firing circuits installed on insulators?
- 68. Are permanent shot-firing circuits installed on the side of the entry opposite the trolley and other power wires?

Telephone Circuits

- 69. Are telephone circuits used?
- 70. Are telephone circuits protected from mechanical injury?
- 71. Are telephone circuits installed on the side of entries opposite the trolley and other power wires?
- 72. Are telephone circuits protected from contact with trolley or power circuits where they must necessarily cross over them?

Signal Circuits Operated from Power Circuits

- 73. Are signal circuits operated from power circuits used?
- 74. Are signal circuits operated from power circuits mounted on insulators?
- 75. Is the operation of bell signals from power circuits prohibited?
- 76. Are sufficient insulators used to keep the circuits from contact with rock, coal or timber?

Battery Signal Circuits

77. Are battery-signal circuits used?

78. Are battery-signal circuits installed on side of entry opposite trolley and other power wires?

79. Does voltage used on battery-signal circuits exceed 24 volts?

Protection of Circuits

80. Are all circuits leaving generating and substations provided with current-interrupting devices which will operate when the current in the circuits exceeds the carrying capacity of the wires?

81. Are transformers in underground stations equipped with automatic circuit-opening devices on the primary side?

82. Are transformers in underground stations equipped with automatic current-interrupting devices on the secondary side?

Power Plants and Substations

83. Are insulating mats provided for attendant to stand on when manipulating or adjusting live electrical machinery?

84. Are insulating mats provided in front of switchboards?

85. Are any live high-voltage parts exposed on front of switchboard at a distance of less than 7-1/2 ft. from the floor?

86. Are live parts on back of switchboard inclosed or protected by position against persons coming into inadvertent contact with them?

87. Is sufficient space provided for free movement where regular passing is required or permitted about machinery?

88. Are power plants and substations well lighted?

89. Are underground stations well ventilated?

90. Are underground stations of fireproof construction?

91. Are all underground transformer stations provided with noncombustible, self-closing doors that will operate in case of fire?

92. Are all underground transformer stations so arranged that oil cannot escape from the room?

Electrically Operated Hoists

93. Are electrically-operated shaft hoists provided with a device to prevent overwinding?
94. Are hoists used in handling men provided with a device to prevent overwinding at main landing?
95. Are hoisting drums provided with brakes that will give adequate protection in all contingencies?
96. Are man hoists provided with automatic devices to prevent overspeeding?
97. Are safety devices for electrically-operated hoists inspected daily?
98. Is a permanent record kept of these inspections?

Electrically Operated Fans

99. Are electrically-driven main mine ventilating fans installed in fire-proof buildings or inclosures?
100. Are fan motors furnished with duplicate electric service lines?
101. Does the responsibility for the operation of the fan fall upon an authorized person?

Information Circular, Bureau of Mines, Department of Commerce.





Circular No. 6038

June, 1927.

STATE GEOLOGICAL SURVEY  
GEOL

## INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

## THE CHROMIUM SITUATION FROM A DOMESTIC STANDPOINT

By J. W. Furness.

The purpose of this résumé is to call attention to the rapid expansion of the chromium industry and to indicate the present and the potential sources of chromium.

## PROPERTIES

In the periodic system, the metal chromium belongs to the oxygen group, which includes molybdenum, tungsten and uranium. Of the elements known, more than one-half form only 4 or 5 per cent of the earth's crust. Among these is chromium, and, therefore, it may be designated as a rare metal. Metallic chromium is crystalline and brittle, harder than glass, bluish-white in color, has a high metallic luster, and crystallizes in the cubic system. Its specific gravity at 20°C. is 6.92; its mean specific heat (0 to  $t^{\circ}$  up to 600°C.), is 0.1039 to 0.00000003 $t^2$ ; it melts at 1520°C., and boils at 2200°C.; it has an atomic weight of 52, and its valence is 2 to 6. Chromium is dissolved slowly in cold and rapidly in hot hydrochloric acid; slowly in dilute nitric and sulphuric acid; but rapidly in concentrated sulphuric acid. Hot concentrated nitric acid does not attack it. Electrolytic chromium is not affected by air, oxygen or chlorine at any temperature up to 300°C. At temperatures above 1200°C. it oxidizes. An alloy of 20 per cent chromium and 80 per cent nickel has the noncorrosive qualities of both metals.

In tests of mineral specimens with the blow pipe, chromium is usually determined by the color it gives to fluxes, and to beads of borax or salt of phosphorus. The salt of phosphorus bead when fused in the oxidizing flame turns a fine green color, and is the most characteristic of chromium beads.

Chromium is not found as a native element but generally as chromite ( $\text{Cr}_2\text{O}_3\text{FeO}$ ), the only chromium mineral now used commercially. Chromite is blackish-brown in color, gives a brown streak, has a sub-metallic luster, a hardness of 5.5 and specific gravity of 4.32 to 4.57. Its crystalline form is octahedral.

## CHROMITE DEPOSITS

Most chromite deposits occur as lenses, kidneys or irregular bodies, which may be more or less pure chromite or may contain more or less disseminated particles. In South Africa some deposits are bedded. Chromite deposits lie in or are associated with basic igneous rocks, such as pyroxenite or olivinite, or are in serpentine, talc schists, and other rocks that were formed by the alteration of basic igneous rocks. Because of the geologic occurrence and the history of chromite deposits it is highly probable that new discoveries will be made throughout the world. Detrital and alluvial deposits of chromite, derived from the decay of chromite-bearing serpentine, are known. Only a few deposits of this character proved to have commercial importance.

## METALLURGY

Metallic chromium. -- The only method in commercial use for the reduction of metallic chromium is the thermit process, which is based on the reaction between aluminum and chromic oxide. The chromic oxide ( $\text{Cr}_2\text{O}_3$ ) used in this process is obtained from sodium bichromate reduced with sulphur, according to the equation  $\text{Na}_2\text{Cr}_2\text{O}_7 + \text{S} = \text{Na}_2\text{SO}_4 + \text{Cr}_2\text{O}_3$ . The chromic oxide obtained is mixed with aluminum and placed in a magnesite-lime furnace. After combustion has started, an exothermic reaction, ( $\text{Cr}_2\text{O}_3 + 2\text{Al} = 2\text{Cr} + \text{Al}_2\text{O}_3$ ), takes place and no external heat is necessary. The heat of formation of  $\text{Al}_2\text{O}_3$  is 392,600 calories per gram, and that of  $\text{Cr}_2\text{O}_3$  is 243,900 calories. The purity of the metallic chromium made depends on the grade of the chromic oxide, which usually is free from carbon and other impurities. Generally, a small amount of aluminum remains in the metal, which contains 99.5 per cent chromium. A proposed method of manufacturing metallic chromium is by the reduction of chromic oxide with calcium carbide (British patent 152,399). A French method consists of grinding, to 10 mesh or less, a high carbon ferrochrome (carbon in excess of 12 per cent), and mixing the ground material with sodium bicarbonate. Thermic action can be induced and the resultant product is sodium bichromate that virtually is chemically pure. This bichromate may be reduced to the metallic state by one of the processes outlined.

For the grades of material demanded by the trade three distinct metallurgical methods are in use; they are: (1) The smelting of chromite in the electric furnace to produce ferrochrome, (2) the manufacture of chromates and bichromates by the chemical treatment of chromite, (3) the production of metallic chromium, by extracting chromium oxide from chromite, as outlined above, and reducing this oxide to metal by the thermit process.

Ferrochrome is an alloy of chromium iron and carbon; to be acceptable to the trade it must contain not less than 60 per cent of chromium. Ferrochrome is made by reducing the crude ore or concentrate in the electric furnace. The alloy tends to take up much carbon, and as carbon is considered undesirable, the quality and price are in inverse proportions to the carbon content. At present the commercial manufacture of ferrochrome involves the use of carbon, and no equally satisfactory method of manufacture without carbon is known. The electric furnace is charged with chromite and anthracite. True reduction which begins at  $1,185^\circ\text{C}$ ,



is based on the reaction  $\text{FeO} \cdot \text{Cr}_2\text{O}_3 + 4\text{C} = \text{Fe}_2\text{Cr} + 4\text{CO}$ . In practice, however, the amount of carbon necessary greatly exceeds the theoretical requirements. In order to decarburize the high-carbon ferrochrome, the alloy is melted with chromite ore fluorspar, and a slag containing a high percentage of lime<sup>1/</sup>.

Chromates and bichromates. - In the manufacture of chromates and bichromates of sodium and potassium, a chromite ore free from sulphur and containing more than 40 per cent  $\text{Cr}_2\text{O}_3$  is required. If the ore carries sulphur, a preliminary roasting is necessary. The sulphur-free ore is mixed with sodium carbonate and limestone, then roasted in a reverberatory furnace for 8 to 20 hours. The reaction that takes place is probably as follows:  $2\text{FeCr}_2\text{O}_4 + 4\text{Na}_2\text{CO}_3 + 7\text{O} = \text{Fe}_2\text{O}_3 + 4\text{Na}_2\text{CrO}_4 + 4\text{CO}_2$ .

The chromate is dissolved with boiling water and the calcium in solution is precipitated, by the addition of sodium sulphate, as calcium sulphate, leaving the chromium in solution. The solution is decanted and evaporated until the sodium chromate crystallizes. A purer product is obtained by washing the crystals in a centrifugal washer, drying and heating. The crystals, which contain about 95 per cent sodium chromate, crumble to a yellow anhydrous powder. By adding sulphuric acid to the sodium chromate crystals, sodium bichromate is produced. The reaction is represented by the following equation:  $2\text{Na}_2\text{CrO}_4 + \text{H}_2\text{SO}_4 = \text{Na}_2\text{Cr}_2\text{O}_7 + \text{H}_2\text{O} + \text{Na}_2\text{SO}_4$ .

### USES

Chromium was unknown to the ancients, and was first studied by L. N. Vauquelin and Marquart in 1786. For many years there was little demand for the metal and the annual consumption was relatively small. The general use of chromium in the form of bichromates dates back to the first recognition of the properties imparted to leather in the tanning industry. In 1909 the domestic production of chromite was 598 tons, and the imports were 39,624 tons. In 1925 there was a small domestic production, although 108 tons were shipped from stocks of ore previously mined; the imports were 149,739 tons. For 1926, it is estimated that the domestic production will be negligible and imports will exceed 200,000 tons. This clearly illustrates the rapid expansion of the industries that utilize chromium.

Chromite, as has been stated, is the only chromium mineral used commercially. Theoretically, chromite contains 68 per cent chromium sesquioxide, and 32 per cent iron protoxide, but as found in nature it usually carries impurities. Some of the iron may be replaced by magnesium and some of the chromium by aluminum and ferric iron. The usability of chromite ores depends on the ratio of iron to the chromium content, and also upon the ratio of the chromium to the alumina, magnesia and silica. An ore in which iron predominates is not usable, nor can it by any known process be made to yield a concentrate acceptable to the manufacturers of ferrochrome.

As the United States is the greatest consumer of chromium, the uses of chromium in this country are assumed to be typical. In 1925 the domestic consumption was proportioned approximately as follows: manufacture of ferrochrome (for metallurgical use), 32 per cent; for chemicals, 27 per cent, and for refractories, 41 per cent. An approximate distribution of the chromite used in refractories was: In bricks 88 per cent, in cement 10 per cent, as ore 2 per cent.

<sup>1/</sup> Lyon, D.A., Keeney, R.M., and Cullen, J.F., The Electric Furnace in Metallurgical Work: Bull 77, Bureau of Mines, 1914, pp. 131-141.

## METALLURGICAL USES

Ordinary chrome steel contains about 2 per cent chromium. In the manufacture of chrome steels, ferrochrome must be used because of the metallurgical difficulties, which add to the cost of making these steels direct from chromiferous iron ore. Chrome steels possess great hardness combined with toughness. They can be bent cold, and can be welded to iron to form either a surface or a core that is extremely resistant to the attack of even the finest drilling tools. These uses are many, including the manufacture of axles, springs, parts of gun carriages, automobiles, steel for safes, tires, cutlery steel, projectiles and armor plate. Steels intended to resist abrasive action are alloyed with vanadium, nickel, tungsten and manganese, in addition to chromium.

Rustless steel commonly contains 13 to 14 per cent chromium, 1 per cent nickel and is low in carbon; it is chiefly used in the manufacture of cutlery. An alloy known as stellite (essentially cobalt, chromium, and tungsten or molybdenum) is especially suitable for high-speed tools. Nichrome, an alloy of 60 per cent nickel, 14 per cent chromium and 15 per cent iron, resists high temperatures and is used chiefly for annealing boxes and conveyor chains. Stainless steel, which contains 13 to 14 per cent chromium, is used in the manufacture of exhaust valves, turbine blades, pump rods, rollers for bearings, in electric heating stoves, and utensils.<sup>2/</sup>

## CHEMICAL USES

Chromite is of great importance to the chemical industries. From it is obtained the chromium used for making chromates and bichromates. Chrome pigments - yellow, green and red - are widely used. In the dye industry, the soluble chromates and bichromates are used as mordants. They are also used in the tanning of chrome leathers, and in the bleaching of fats and oils. In the ceramic industry the chromic acids and the bichromates are used to color pottery. The United States imports annually considerable quantities of these compounds.

## USES AS A REFRACTORY

The most important use of chromite as a refractory is as a liner for the open-hearth steel furnace. From a study made by its metal section The War Industries Board estimated that  $2\frac{1}{2}$  pounds of chrome were utilized for every ton of steel manufactured. Chromite is used either as bricks or in irregular shapes as mined. Chrome bricks are used as a substitute for magnesite bricks, which are more costly. There is so little difference in service rendered that the superiority of one material over the other has as yet not been definitely determined.

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<sup>2/</sup> Chemical and Metallurgical Engineering, vol. 22, 1919, p. 438.



## OTHER POSSIBLE USES

Of the newer uses of chromium, one of the most interesting is for coating metals<sup>3/</sup>. In this country and abroad, the electrolytic plating of various metals with chromium is now on a commercial basis. The coating is hard and white, resembling platinum; it resists the action of ammonia fumes, hydrogen sulphide, and nitric acid, and is not attacked by molten zinc, tin or brass. It is said that chromium adheres more closely to the metal on which it is placed than does nickel, and a brilliant finish can be obtained without polishing. It is being increasingly used for automobile finishing and for plating bearings. As chromium is not corroded by vegetable and fruit acids, it may possibly supplant tin for some purposes. The research work that has been done on chromium alloys for resisting corrosion and high temperatures bids fair to revolutionize some of the older industrial processes and to make new ones possible.

## SUBSTITUTES

For the manufacture of certain steels there is no known substitute for chromium. In tanning also, no satisfactory substitute has been found. For pigments chromates may be replaced, but as a rule, to which the exceptions are few, the substitutes are more expensive. As a refractory in electric furnaces for making steel, chromium may be said to be interchangeable with magnesium. In steel furnaces operated at lower temperatures, chromite bricks may be replaced by magnesite bricks, but magnesite bricks are usually more expensive.

## CONSUMPTION AND PRODUCTION

In 1925 the world's consumption of chromium was in round numbers 250,000 tons. The imports into the United States were 149,739 long tons, valued at \$1,207,420. The domestic production, represented by shipments from stocks of previously mined ore, was 108 tons, valued at \$2,105. In addition to the chromite ore imported in 1925 the following chromium compounds were imported: Chromic acid 5,564 pounds; chromate and bichromate of potash, 4,379 pounds; chromate and bichromate of soda, 221 pounds, and chromium chloride and sulphate, 3,520 pounds. The United States

<sup>3/</sup> Engineering and Mining Journal-Press, "Plating base metals with chromium": Vol. 120, 1925, p. 624. The Metal Industry, "The corrosion resistance of chromium-plated steel." Ollard, E. A., vol. 27, 1925, pp. 235-237. The Metal Industry. "Notes on the plating of chromium on steel," Enos, Geo. M., vol. 27, 1925, pp. 261-262. The Metal Industry, "Chromium plating--a warning," vol. 27, 1925, pp. 331-332. Canadian Mining Journal, "Chromium plating of steel," vol. 45, 1924, p. 1105. The Chemical Age, "Chromium-plated steel," Feb. 6, 1926, vol. 14, p. 12. General Survey of Chromium Plating, by E. A. Ollard, A. R. C. Sc. Anodes--Theory of Working--Corrosion--For Motor Car Head Lamps--For Cutlery and Tableware--For Reflectors, Compared with Silver. Miscellaneous Domestic and Industrial Uses--For Printing Plates and Machine Parts--Chromium Plating--Castings--Cost, Compared with Nickel Plating--Conclusions. American Metal Market (Monthly review section), vol. 33, Mar. 18, 1926, pp. 9-10.



consumed 60 per cent of the total world's production.

Estimated percentage of production and consumption  
1925, by countries.

Country	Production	Consumption
United States .....	---	60.
England .....	---	11.2
France .....	---	8.6
Germany .....	---	11.1
Rhodesia .....	41.1	---
New Caledonia .....	11.6	---
Cuba .....	8.6	---
Turkey (Asia Minor) .....	---	---
India (Baluchistan) .....	16.7	---
Russia .....	10.2	---
Union of South Africa .....	3.8	---
	92.0	90.9

In the above table consumption means the amount necessary to satisfy the trades of the specific country, without regard to exports. If, for example, an industry in some country requires a certain amount of chromite for the manufacture of ferrochrome, and the exports of ferrochrome actually decrease consumption in that country, the amount exported has no influence upon the amount needed to satisfy the trade in this metal.

Consumption and production of chromite in the United States clearly illustrate how an industry of considerable magnitude may depend entirely upon uncontrolled sources for its raw material. Chromite is but one of several metals - for example, manganese, tin and possibly mercury - that occupy a like position. In 1925 the United States required, to satisfy its trade demands, fully 60 per cent of the world's production of chromite, 52 per cent of that of tin, and 30 per cent of that of antimony, although its production of each of these metals was negligible. It also required 25 per cent of the world's production of mercury although it produced but 10 per cent, and 39 per cent of the world's production of manganese although it produced only 4.3 per cent.

In 1827 the Reed mine at Jarrettsville, Hartford County, Md., was developed by Isaac Tyson of Baltimore, and from it was mined the first chromite produced in the United States. From that date to and including 1925, the total production in the United States of ore containing more than 30 per cent  $\text{Cr}_2\text{O}_3$  was 577,404 tons. Of this production 137,589 tons was mined during the war period of 1917 and 1918. For the year 1926 the imports of standard grade ore (ore carrying 48 per cent or more  $\text{Cr}_2\text{O}_3$ ) amounted to 215,464 tons. In other words, the gross production from domestic mines during a century of operation is equivalent to less than three years' supply as measured by the present rate of imports.

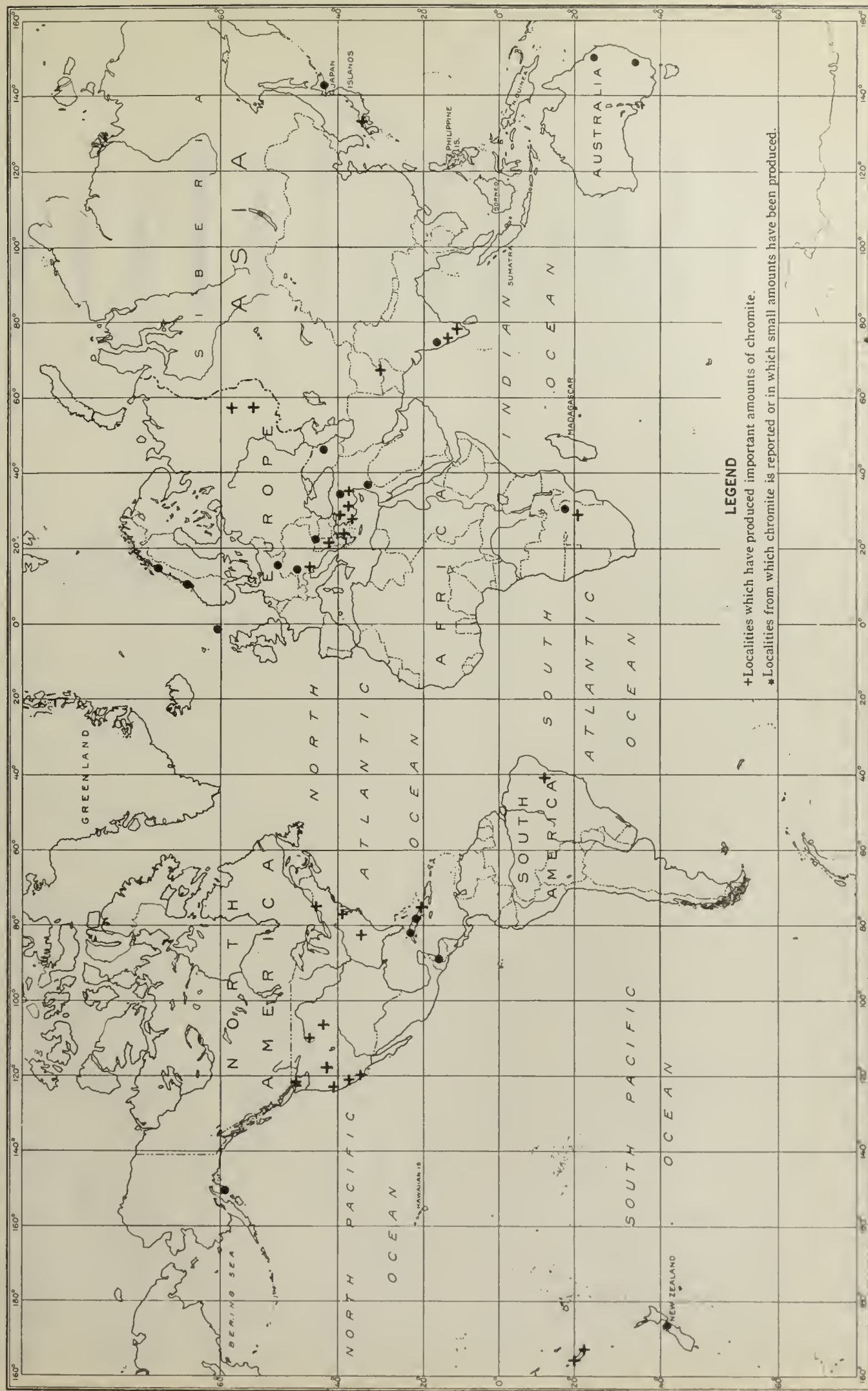
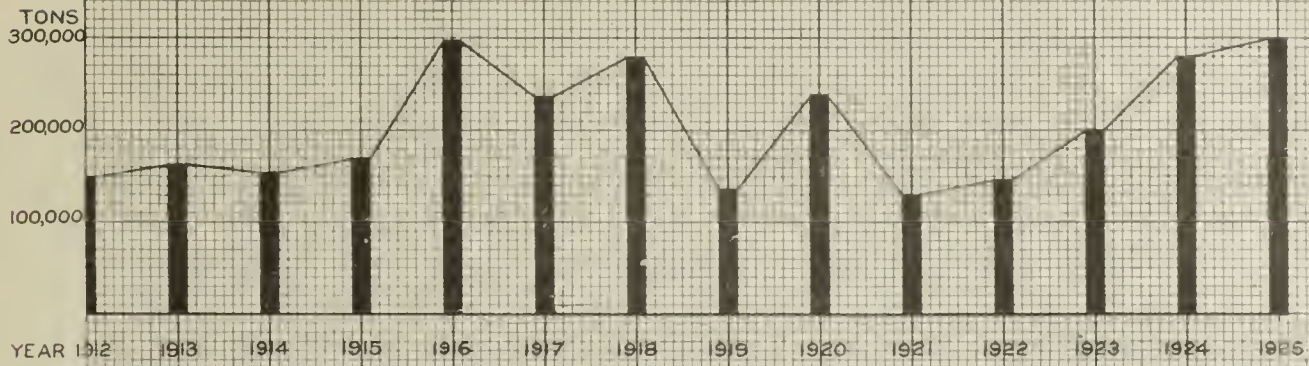


FIG. 1 -- GEOGRAPHICAL DISTRIBUTION OF THE CHROMITE DEPOSITS OF THE WORLD.

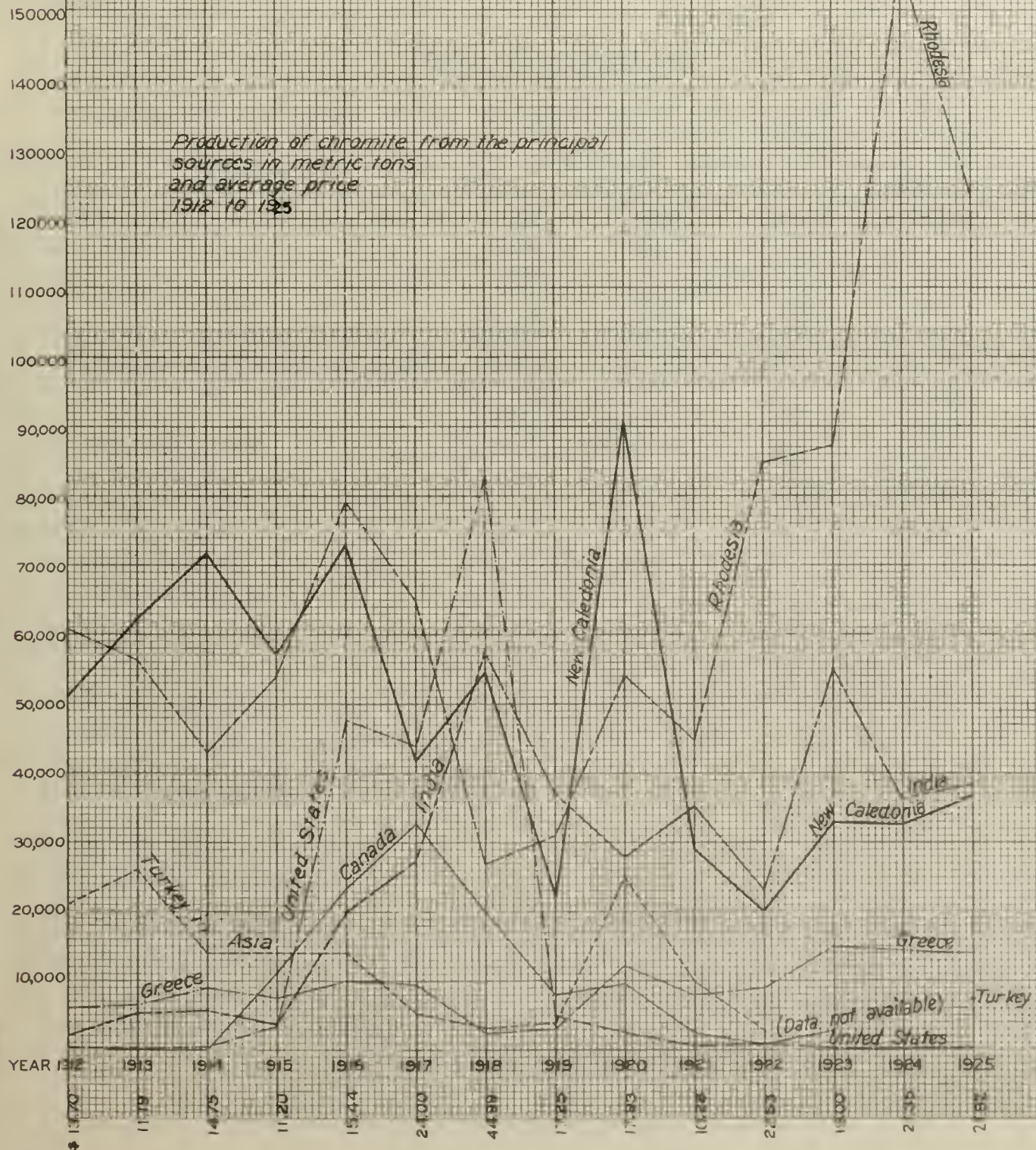




# WORLD'S PRODUCTION OF CHROMITE IN METRIC TONS FROM 1912 TO 1925 INCL.



Production of chromite from the principal sources in metric tons and average price 1912 to 1925







An interesting point in the history of chromite mining is that several countries have held the position of largest producer. From 1830 to 1870 the United States, through the shipments from the state of Maryland, led the world. In 1848 chromite was discovered in the province of Brusa, Turkey, but not until about 1860 did production there contribute an appreciable quantity to the world's markets. From 1870 to 1903, however Turkey was the principal source of the world's supply of chromite. Intensive development in New Caledonia and Southern Rhodesia enabled those countries to furnish, in approximately equal shares, about three-fourths of the total supply from 1908 to 1922. In 1922 and 1924 Southern Rhodesia produced more chromite than all other countries combined. In 1918 the United States was the leading producer, mining 82,430 long tons<sup>4/</sup>, but this output had an average grade far below that of the normal commercial ore, cost enormously more per pound of chromium, and the output was possible only because the exigencies of war cut off other sources of supply.

## WORLD'S PRODUCTION

Production of crude chromite, 1921-1925, by countries, in metric tons<sup>1</sup>

Country	1921	1922	1923	1924	1925
Australia .....	63	537	1,211	785	978
Canada .....	2,538	696	5,228	---	---
Cuba .....	<u>2/</u> 610	---	<u>2/</u> 10,587	<u>3/</u> 19,881	<u>3/</u> 25,689
Great Britain .....	---	605	555	1,060	(4)
Greece .....	8,029	9,213	14,828	14,651	(4)
Guatemala .....	<u>2/</u> 407	---	---	---	---
India .....	35,320	23,145	55,113	46,192	(4)
Japan .....	5,368	3,757	4,526	5,562	(4)
New Caledonia <sup>5/</sup> .....	29,458	19,374	23,220	23,021	34,732
Rhodesia, Southern .....	45,529	84,799	87,702	156,692	123,220
Rumania .....	---	30	60	---	(4)
Russia <sup>6/</sup> .....	4,013	847	3,004	7,266	30,670
Turkey (Asia Minor) .....	(4)	<u>7/</u> 2,540	(4)	(4)	(4)
Union of South Africa .....	1,078	87	---	4,572	11,316
United States .....	287	301	231	293	110
Yugoslavia .....	<u>10</u>	<u>15</u>	(4)	300	(4)
	130,710	146,004	204,265	280,075	(4)

<sup>1/</sup> Compiled by L. M. Jones, of the Bureau of Mines.

<sup>2/</sup> Imports into the United States.

<sup>3/</sup> Production of the Caledonia mine.

<sup>4/</sup> Data not available.

<sup>5/</sup> Exports.

<sup>6/</sup> Data for year ended Sept. 30.

<sup>7/</sup> Approximate production.

<sup>4/</sup> During the war period requirements as to grade were greatly modified. Material that normally would not find a market was accepted as ore. The average grade of the ore produced during the war was 41 per cent Cr<sub>2</sub>O<sub>3</sub>, whereas 43 per cent Cr<sub>2</sub>O<sub>3</sub> is the grade normally required.



At present the world's supply of chromite is drawn mainly from two great sources, Southern Rhodesia and New Caledonia. Other countries and regions that have deposits of chromite but produce little or no ore are: Western and southern Asia Minor: Ural Mountains; Russia; eastern Greece, adjacent islands, and Macedonia; Serbia; Bosnia and Herzegovina, Austria-Hungary; Shetland Islands, Scotland; Norway; Sweden; Silesia, Germany; Portugal; Quebec, Canada; Newfoundland; Atlantic and Pacific coast States, United States; State of Bahia, Brazil; Guatemala; New South Wales, Australia; New Zealand; Transvaal, and Togoland.

## RESOURCES

Present knowledge indicates that the world's major resources of chromite are in South Africa (Southern Rhodesia), New Caledonia, and western Asia Minor (Anatolia). In addition to the high-grade ore found in the countries mentioned, a large potential reserve of what is known as chromiferous iron ore, is found in Cuba, Celebes, the Gold Coast and Greece. These chromiferous iron ores contain a fraction of 1 per cent to 3 per cent chromium, associated with a small percentage of nickel. The Cuban deposits in the district of Mayari have been estimated to contain upwards of 2,000,000,000 tons of such ore and those of the Celebes more than 1,400,000,000 tons.

### South Africa (Rhodesia)

The reserves of Rhodesia seem ample to supply the world's present needs for many years. They are probably of greater commercial importance and are more extensive than any others now known.

In 1911, The Chrome Company, Limited, of London was formed, and through an agreement with the owners of the deposits then worked in Rhodesia was able to dominate the world's market.

The ores of the principal mines, which are in the Selukwe district, have been described by A.E.V. Zeally in the "Geology of Chrome Deposits of Selukwe, Rhodesia."<sup>5/</sup> The most striking feature of the occurrence of chromite in Rhodesia is that the most important deposits are in talc-schists, and in carbonate and talc-carbonate schists, chlorite schist, serpentine, and silicified serpentine. It seems probable that the schists may be crushed and altered serpentines or that the serpentines and other rocks may have been formed by the alteration of a group of basic rocks that were much alike. As a rule, the bodies of chromite are near the margin of the talc-schist areas, but occasionally they pass into the adjacent rocks.

More than 130 lenses of chromite ores have been mapped, by far the larger number ranging from 150 to 400 feet long. In the principal chromite mine 8 or 10 large bodies are being mined by open pits which had yielded up to 1922, more than 450,000 tons. Owing to the size and the nature of the deposits, most of the ore can be shipped without concentration, a large amount of low-grade ore is available.

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<sup>5/</sup> Trans. Proc. Geol. Soc., South Africa, 1914, vol. 17, pp. 60-74.

Chromite deposits occur also in the Lomagundi, Victoria, and Makwiro Districts.<sup>6/</sup> The ore in these three districts averages 45 per cent  $\text{Cr}_2\text{O}_3$ .

To the end of 1925 Rhodesia had produced 750,000 tons. The known reserves are estimated to be 2,000,000 tons of 50 per cent ore, in addition to a very large amount of concentrating ore, but the indications are that the potential reserve of high-grade ore is larger than estimated.

### New Caledonia

In New Caledonia all of the important deposits are in serpentine in the southern part of the island. Mining began in 1866, and in 1880 some ore was exported. Three general types of deposits are found: Rock chromite, consisting of solid ore bodies; residual chromite; and chromite sands and gravels in stream deposits. Only the first two types are commercially important. Some of the ore bodies are very large. One open cut produced more than 200,000 tons of chromite that averaged 55 per cent  $\text{Cr}_2\text{O}_3$ . In 1921 the island was prospected rather carefully but no new bodies of ore were discovered.

Some of the principal mines are the Lucky Hit, Fensee, Alice Louise and Tiebaghi. The last named mine at times has produced 5,000 tons per month of ore, averaging 55 per cent  $\text{Cr}_2\text{O}_3$ . The size of the ore bodies is indicated by the history of the Borcingstorix Mine, at Unia, on the east coast, 63 miles from Noumea. This mine was opened in 1913 and was exhausted by 1919. The total production was 60,000 tons of an average grade of 55 per cent. During 1921 the Société Le Nickel started the construction of a hydroelectric plant at Yate on the east coast. According to the management, this plant will manufacture ferrochrome and ferronickel.

Very large bodies of ore suitable for concentration are undeveloped, but in time will be mined. The total production to the end of 1925 has been 885,000 tons. The reserves, not considering the alluvial chromite or the concentratable rock, are estimated to be more than 1,500,000 tons of 50 per cent ore.<sup>7/</sup>

### Turkey

The principal deposits of Asia Minor are in the Province of Brusa. They were discovered in 1843, but did not supply an appreciable part of the world's output until about 1860. For a number of years before 1903, Turkey supplied half of the world's production, but the development of the New Caledonian deposits cut down the Turkish output. For some years before the War, the production was 10,000 to 15,000 tons per annum, which could have been raised to 200,000 tons per annum had the demand been stronger. The Daghargi or Alabarda mines, some 40 kilometers south of

<sup>6/</sup> Rumbold, W.G., Chromium Ore; Imperial Institute Monograph, 1921, p. 21.

<sup>7/</sup> Compton, Geo., "New Caledonia and the Isle of Pines": Min. Jour., London, vol. 49, 1917, p. 714. "Chromite industry of New Caledonia": Min. Jour., London, vol. 134, 1921, p. 714. "Mineral industry in Caledonia": Min. Jour., London, vol. 141, 1923, p. 446.



Brusa, have produced to date 350,000 tons, and are estimated to contain more than 10,000,000 tons of high-grade ore. The total Turkish reserves are estimated to be about 15,000,000 tons of 50 per cent ore.

#### United States

Investigations of domestic chromite deposits carried on during the War indicated that the United States possesses large reserves of low-grade, high-cost chromite which would be sufficient to meet domestic needs for six or seven years at the present rate of consumption; though a lowering of standard grades and a rise in price would both be necessary to bring about the mining of such reserves. In fact, if the domestic reserves were to be measured by present trade standards as to either tenor or price, the United States, would be without chromite. In addition to the ore that is known, there are certain localities, as in Montana for example, where geological indications suggest that other ore-bodies would be proven by further prospecting and development. The available reserves of usable ores, credited to this country are estimated at 1,252,600 tons; and are in some 2,000 scattered deposits in eight States. In 1918 there were 450 shippers as follows: California, 374; Oregon, 60; Washington, 1; Alaska, 2; Montana, 3; Wyoming, 1; Pennsylvania and Maryland, 3; North Carolina, 5; and Georgia, 1. During the World War, the largest single body mined in this country was exhausted after producing 16,000 odd tons of high-grade ore. Most of the reserves represent concentrates derived from the beneficiation of ore having a tenor of 10 per cent or more of  $\text{Cr}_2\text{O}_3$ . The grade of the crude ore shipped during the time of forced production, 1917 and 1918, was 41 per cent, whereas present specifications call for an ore running 45 per cent  $\text{Cr}_2\text{O}_3$  as a minimum. The price quoted by the Engineering and Mining Journal, October 9, 1926, was \$21 to \$24 for ore carrying 45 to 50 per cent  $\text{Cr}_2\text{O}_3$ , f.o.b. Eastern shipping points. At an average of \$48 (war dollars) per ton, some 80,000 tons were produced in 1918. Production of a like quantity again would require higher prices. However, any statement of the probable relation of price to output must be largely a matter of individual opinion. The accompanying table gives the writer's opinion as to the production from the reserves in the United States, if prices were to advance as indicated.

Period	Price per ton <sup>1/</sup> in pre-war dollars	Total successive tonnage for three-year period
First 3 years	40	320,000
Second 3 years	50	300,000
Third 3 years	60	200,000
Fourth 3 years	70	300,000 <sup>2/</sup>

<sup>1/</sup> It is assumed that the present dollar has a pre-war value of 60 cents.

<sup>2/</sup> The rise is due to attainment of full capacity by concentrating plants.

If extreme forcing of production were necessary, the writer assumes that the domestic reserves might be exhausted in 3 years with chromite at \$70 per ton; but if the price were to advance successively through a 12-year period, the production would probably be as outlined in the table. It is evident that estimates of

available reserves must be based first on the requirements of the trade, and established by chemical and metallurgical uses, and second, on a price per ton that will bring out the required amount. The United States has no appreciable reserves that could be mined at a profit with 50 per cent ore selling at \$32 a ton, but it has deposits that would become available if the price were high enough.

### POLITICAL AND COMMERCIAL CONTROL

The political and commercial control of chromite now rests largely with England. Until 1911 virtually all the chromite mined in New Caledonia was shipped by French companies, but in that year a consolidation was made with the Chrome Company, Ltd., of London; a sales contract was made with the Rhodesian Chrome Mines, Ltd. Thus the Chrome Company, Ltd., controls the larger part of the world's output. There are several small independent producers in New Caledonia, the most important being a company controlled by citizens of the United States. In 1914, the Chrome Company, Ltd., took over the largest producer in Baluchistan. The Indian production from Mysore Province, amounting to 11,863 tons in 1925, seems to have been independent of the control of the Chrome Company, Ltd.; it was shipped through Japanese, British and American agencies.

For many years before the World War, the Brusa deposits of Anatolia were operated by J. W. Whittall & Co., an English firm, as lessees. During the War the deposits were worked by agents of Frederick Krupp, but since 1918 there have been no shipments.

Since 1922 the development of chromite mining in Rhodesia has expanded rapidly, and the control of the chromite supplies, which had been in the hands of the Chrome Company, Ltd., has been considerably weakened. There are now many independent shippers.

### DOMESTIC TARIFFS

Chromite ore was subject to a duty of 15 per cent from 1883 until 1894, when it was put on a free list, where it has remained under succeeding tariff laws. Although under the tariff act of 1922, chromite or chromite ores are free of duty, under paragraph 72 of the same act, "chrome yellows, chrome greens, and other colors containing chrome in pulp, dry or ground in or mixed with oil or water," are subject to a duty of 25 per centum ad valorem.

### MARKETING

As a rule, the needs of the trade are supplied through yearly contracts. The value of the ore varies with the uses to which it is to be put. Ores for refractory purposes are bought on a flat basis at so much per unit for a  $\text{Cr}_2\text{O}_3$  content of 40 per cent or more and subject to rejection if this content is less than 38 per cent, the silica content not to exceed 8 per cent. The ferrochrome and chemical trades require an ore containing 50 per cent  $\text{Cr}_2\text{O}_3$ ; premiums are paid for higher content and penalties imposed for lower. Prices are quoted on a unit basis, that is, at so many cents per long ton unit. A unit means 1 per cent of the amount weighed as a measure; that is a long ton unit is 1 per cent of 2240 pounds, or 22.4 pounds of  $\text{Cr}_2\text{O}_3$ .



During the War domestic purchases were made on the basis of f.o.b. railway car. At present, quotations as published in trade journals, represent c.i.f. shipment, which means cargo, insurance and freight paid to Atlantic seaboard.

Occasionally low-grade ores which have been beneficiated contain too much iron to be saleable. Iron in excess of 13 to 20 per cent is not desirable.

#### SOME CHROMITE AGENCIES

Associated Metals & Minerals Corp., 100 E. 42 St. N.Y.  
Agnew, Batteiger & Co., Widener Bldg., Phila., Pa.  
Everett & Co., Ltd., 40 Chapel St., Liverpool, Eng.  
Chas. Gitlan, 35 Nassau St., N.Y.  
Harbison-Walker Refractories Co., Pittsburgh, Pa.  
Charles Hardy, Inc., 100 E. 42nd St. New York.  
H. Hollesen, Inc., 17 Battery Place, New York.  
Int'l. Minerals & Metals Corp., 61 Broadway, New York.  
Iron & Ore Corp. of America, 11 Broadway, New York.  
C. W. Leavitt & Co., 30 Church St., New York.  
Metal & Thermit Corp., 120 Broadway, New York.  
Mitsui & Co., Ltd., 65 Broadway, New York.  
Philipp Bros. Inc., 233 Broadway, New York.  
Ralph Metals Corp., 4601 Woolworth Bldg., New York.  
Rogers, Brown & Crocker Bros., Inc., 21 E. 40th St., N.Y.  
Frank Samuel & Co., Philadelphia, Pa.  
Arthur Seligman, 165 Broadway, New York.  
C. Tennant Sons & Co. of N.Y., 19 W. 44 St., New York.  
United States Nickel Co., New Brunswick, N.J.  
Walter-Wallingford & Co., Cincinnati, O.

Information Circular, Bureau of Mines, Department of Commerce.

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Circular No. 6043  
June, 1927.

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE, BUREAU OF MINES

FATAL ACCIDENT FROM ENTERING UNVENTILATED RAISE AFTER BLASTING

By E. D. Gardner<sup>1</sup>

In a recent accident in a Western metal mine, one man was killed and seven others were overcome by the gases from blasting in a raise.

The raise was 81.5 feet high and 5 by 8 feet in elliptical cross-section. It was divided into two compartments, manway and ore chute, by stulls placed at 5-foot intervals and lined on the chute side with 2-inch plank. The manway, 2-1/2 by 4-1/2 feet in size, was reached from the drift floor by a 12-foot ladder placed at an angle and extending into the manway; thence a ladder fastened to the cross stulls extended vertically to a landing 45 feet from the bottom of the raise. The ladder was offset at the landing and extended to the last stull, about 8 feet from the back of the raise.

The compressed-air line and the water line in the manway were fastened to the partition stulls on which the chute lining was nailed. Valves for shutting off both air and water were provided at the foot of the raise, and also at the ends of the pipes above the landing. Compressed air from the pipe line was the only means of ventilating the raise. The raise was in a cross-cut 20 feet off a main haulage and ventilation drift, on the 1300-foot level. The raise was being run by an experienced miner, who was about 25 years of age and weighed about 175 pounds. He was assisted at blasting time by a trammer, who pulled the chute.

The rock at the back was difficult both to drill and to break. A 3-1/2 or 4-foot round of about sixteen holes was finished during the first part of the afternoon shift, loaded with about sixty-six 1-1/4 by 8-inch cartridges of 40 per cent strength gelatin dynamite and blasted at 8.30 p.m. Fuse and No. 8 detonators were used for shooting the round. The miner was supposed to use stemming, but whether he did is not known. A bulkhead was built over the manway at the top stull and the chute left open at the top. The end of the air pipe was 25 feet below the bulkhead and above the landing. After spitting the round the miner came through the bulkhead, replaced the timber, and opened the air valve on his way down the ladder.

A rule exists at the mine that no one shall go into a raise the same day it is blasted. A second rule also was in force that all raises must be open and safe on the 15th and last days of the month so that the engineers can reach the back to measure the progress. In this case the two rules were in conflict and the first one was violated.

1 - Mining engineer, Bureau of Mines.



At the supper hour (9.00 p.m.) the shift boss on this level told the miner that as the next morning was measuring day, if possible he would like to have the raise made safe for measuring. It was noted at this time that the compressed-air line was not blowing in the raise, and it was suspected that a rock had come through the bulkhead, hit the valve and closed it. At this mine the valves are open when the handle is at right angles to the pipe. The miner told the trammer to wait about one and one-half hours, then go up and open the valve. After the smoke had cleared out, the miner would open the bulkhead and bar down the back.

About this time the shift boss sent the trammer to get some men to work on the ditch. On returning to the raise, the trammer noted the miner's lamp lying on the ground and flashing his light up the raise, saw the miner in the manway. On receiving no answer to his calls he immediately went for help. Evidently the miner had decided not to wait the hour and a half, but to open the valve himself at that time.

The first two men to arrive immediately went up the manway and found the miner suspended by his head, which was caught between the pipe line and a stull about 15 feet below the landing. They were unable to extricate him before they were overcome by gas. Rescuer No. 1, who was above the miner, caught in the ladder upside down. No. 2, who was below, fell 25 feet to the drift floor. The next man to arrive, No. 3 (the shift boss of the level), went up the ladder and brought No. 1 within ten feet of the bottom when he also collapsed and fell to the drift floor with the men he was carrying. The shift boss retained his mental facilities but could not move.

The three men were lying unconscious and No. 4, the trammer, had returned and was looking up the manway, when No. 5, an experienced shift boss from another level, appeared on the scene and recognised the serious conditions. He stayed in the main aircourse, planning his work in fresh air, and had No. 4 describe the condition in the raise -- how the body was caught and other details. No. 2's lamp was alight and hanging on the ladder above the body. No. 5 then told No. 4 to come back from the raise, and for Nos. 6 and 7, who had just arrived, to come with him. The miner's body was now lying horizontally across the raise, still wedged behind the pipe. No. 5, who weighed about 150 pounds, drew the miner's arms around his neck and extricated the body with the assistance of Nos. 6 and 7. No. 5 then carried the body down the ladder to within about ten feet of the drift when he was overcome and fell. His legs went through the rounds of the ladder and held him there; he and the miner's body blocked the manway. Nos. 6 and 7 were feeling the effects of the gas, but were able to get rescuer No. 5 and the miner down to the level. Nos. 5, 6 and 7 were badly gassed, and the others were unconscious.

The mine superintendent now arrived and took charge. The rescued body was hurried to the surface where the physician administered artificial respiration without effect. The miner had been in the raise between 15 and 30 minutes, and was probably dead when he was finally brought to the level. Nos. 1, 2, 3 and 5 were carried into the main drift, and after reviving, were able to walk to the cage with assistance of other miners. The men were taken to the hospital for observation and then sent home. All of the gassed men who participated in the rescue work, except No. 1, were at work the next day. He was off two or three shifts and his mind was not clear for a week.

None of the men who fell was bruised or skinned up. The miners who did the rescue work all agreed that the raise was as "clear as a bell," but there was some disagreement as to odor in the raise. The superintendent stated that he noted no smell of burned powder in the raise when he arrived.

The next morning the superintendent and the deputy State mine inspector inspected the raise and found that the air valve above the landing had not been turned on, but the dead miner's hat was on the landing. Evidently he had had his head above the landing when he was overcome. It was found that the round had not broken and that the concussion had broken the bulkhead in the manway. Although but little rock was loosened by the blast, very likely a fragment came through the bulkhead down the manway and struck the valve on the air pipe.

Undoubtedly the men were overcome by carbon monoxide from the blast. The class and grade of explosive used, as shown by sampling tests by the Bureau of Mines on this explosive at another mine, produces relatively small amounts of carbon monoxide. The gas, however, was confined in a small volume in the raise, which was responsible for a higher concentration. The tests mentioned did not show that an appreciably larger proportion of carbon monoxide was made when the round did not break. Tests have shown that the use of stemming reduces the quantity of carbon monoxide.

The accident was the result of a combination of circumstances: (1) That the next day was measuring day, (2) that the round did not break, (3) that the bulkhead was broken, (4) that a fragment of rock closed the air valve, and (5) that the miner did not wait for a sufficient length of time before going up to open the air valve.

The accident probably would have been prevented had there been an independent method of ventilating the raise furnished, such as a blower and tubing. Such raises are not generally ventilated, for as soon as the miner starts to drill, the air is generally good, and as material is hoisted up the manway, the air tubing would be in the way. — Information Circular, Bureau of Mines, Department of Commerce.





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August, 1927

STATE GEOLOGICAL SURVEY

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INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

LIST OF PERMISSIBLE MINING EQUIPMENT

A complete list of permissible mining equipment, rescue apparatus and gas masks tested prior to January 1, 1927, was published in Bureau of Mines Information Circular 6021<sup>1</sup>. The present list includes all equipment tested and approved by the Bureau, up to and including July 2, 1927. It covers electric air compressors, coal drills, mining machines, loading machines, conveyors, mine pumps, room hoists, rock-dusting machines, switches, electric cap lamps, flame safety lamps, electric hand and trip lamps, flash lamps, methane indicators and detectors, blasting units, storage battery locomotives, power trucks, self-contained oxygen breathing apparatus and gas masks.

The system under which these devices were tested permits the manufacturer, after his equipment has passed certain tests prescribed by the Bureau of Mines, to mark his equipment with a seal showing that it has been "approved" by the Bureau. These tests are designed to insure that the equipment has the minimum requirements for safety in use. The only object of the Bureau in making such tests and publishing lists of permissible equipment is to safeguard the lives of workers and to help lessen the hazards of mining.

PERMISSIBLE MINING MACHINES, COAL DRILLS, ETC.

Approved Under Schedules 2, 2A, and 2B.

Air Compressors

1. Type WK-26 compressor; 30-hp. motor, 250-500 volts, D. C. Approvals No. 117 and 117A, issued to Sullivan Machinery Co., Mar. 12, 1925.
2. Type WK-39 self-propelled compressor; 30-hp. motor, 250-500 volts, D. C. Approvals No. 120 and 120A, issued to Sullivan Machinery Co., July 28, 1925.
3. Type CP-26G, CP-26D and CP-26H compressors; 25-hp. motor, 250-500 volts, D. C. Approvals No. 128 and 128A, issued to General Electric Co., March 21, 1927 and July 16, 1926, respectively.

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1 List of Permissible Mining Equipment, Information Circular No. 6021, Bureau of Mines, February, 1927.



Loading Machines and Conveyors

1. Type 43-A shortwaloader; Jeffrey 50-hp. motor, 250-500 volts D. C. Approvals No. 122 and 122A, issued to The Jeffrey Mfg. Co., Jan. 8, 1926.
2. Type 44-B conveyor-loader; Jeffrey 50-hp. motor, 250-500 volts, D. C. Approvals No. 123 and 123A, issued to The Jeffrey Mfg. Co., Jan. 15, 1926.
3. Belt-type conveyor; South Fork Foundry & Machine Co 5-hp. motor, 250 volts, D. C. Approval No. 126, issued to Bird Coal Co., June 25, 1926.
4. Shovel-type loading machine; General Electric motor 30-hp., 250 volts, D. C. Approval No. 127, issued to Myers-Whaley Co., July 16, 1926.
5. Chain-type conveyor; South Fork Foundry & Machine Co. 5-hp. motor, 250 volts, D. C. Approval No. 129, issued to the Bird Coal Co., July 21, 1926.
6. Type 5-BU loading machine; Crocker Wheeler 25-hp. motor, Ward Leonard controller, 230-500 volts, D. C. Approvals No. 132 and 132A issued to Joy Mfg. Co., December 29, 1926, and March 22, 1927, respectively.
7. Type 49-A chain-type conveyor; Jeffrey 3-hp. motor, 250-500 volts, D. C. Approvals No. 133 and 133A, issued to The Jeffrey Mfg. Co., Feb. 10, 1927.
8. Conveyor-type loader; General Electric 30-hp. motor, 250-500 volts, D. C. Approvals No. 135 and 135A, issued to the Sullivan Machinery Co., May 11, 1927.

Coal Drills

1. Type 2-BF drill; 1-hp. motor, 80-110-250 volts, D. C. Approvals No. 109 and 109A, issued to Chicago Pneumatic Tool Co., Sept. 19, 1922.
2. Type CD drill; 3/4-hp. motor, 110-230 volts, D. C. Approvals No. 110 and 110-A, issued to Martin-Hardsocg Co., Sept. 16, 1922.
3. Type A-5 drill; 3-hp. motor, 110-250 volts, D. C. Approvals No. 119 and 119-A, issued to Jeffrey Mfg. Co., Apr. 15, 1925.

Mining Machines

1. Type CE-7 Ironclad shortwall mining machine; 30-hp. motor, 250-500 volts, D. C. Approvals No. 100 and 100A, issued to Sullivan Machinery Co., Sept. 30 and Oct. 20, 1914, respectively.
2. Types 12-CC and 12-EC shortwall mining machines, 35-hp. motor, 210-500 volts, D. C. Approvals No. 101 and 101A, issued to Goodman Mfg. Co., May 20, 1916.
3. Type 35-B shortwall mining machine, 35-hp. motor, 250-500 volts D. C. Approvals 103 and 103A, issued to The Jeffrey Mfg. Co., Nov. 2, 1917.

4. Type CE-7 Ironclad shortwall mining machine, 30-hp. motor, 220-440 volts, A. C. Approvals 104 and 104A, issued to Sullivan Machinery Co., Jan. 16, 1919.
5. Types 12-CJ and 12-EJ shortwall mining machines, 50-hp. motor, 210-500 volts, D. C. Approvals No. 105 and 105A, issued to Goodman Mfg. Co., June 21, 1920.
6. Types 112-CC and 112-EC shortwall mining machines, 50-hp. motor, 210-500 volts, D. C. Approvals 106 and 106A, issued to Goodman Mfg. Co., Feb. 9, 1922.
7. Types 12-CC and 12-EC shortwall mining machines, 35-hp. motor, 210-500 volts, D. C. Approvals No. 107 and 107A, issued to Goodman Mfg. Co., Feb. 9, 1922.
8. Types 112-CJ and 112-EJ shortwall mining machines, 35-hp. motor, 210-500 volts, D. C. Approvals No. 108 and 108A, issued to Goodman Mfg. Co., Feb. 9, 1922.
9. Type 35-BB shortwall mining machine, 50-hp. motor, 250-500 volts, D. C. Approvals No. 111 and 111A, issued to Jeffrey Mfg. Co., Oct. 16, 1922.
10. Type 29-C arcwall mining machine, 50-hp. motor, 250-500 volts, D. C. Approvals No. 112 and 112A, issued to Jeffrey Mfg. Co., Mar. 13, 1924.
11. Types 212-EJ and 212-CJ shortwall mining machines; 50-hp. motor, 210-500 volts, D. C. Approvals No. 113 and 113A, issued to Goodman Mfg. Co., Nov. 4, 1924.
12. Types 112-CK3 and 112-EK3 mining machines; 35-hp. motor, 220-440 volts, A. C. Approvals No. 114 and 114A, issued to Goodman Mfg. Co., Feb. 7, 1925.
13. Types 112-CL3 and 112-EL3 shortwall mining machines, 50-hp. motor, 220-440 volts, A. C. Approvals No. 115 and 115A, issued to Goodman Mfg. Co., Feb. 7, 1925.
14. Type 124-EJ slabbing machine; 50-hp. motor, 210-500 volts, D. C. Approvals No. 118 and 118A, issued to Goodman Mfg. Co., Mar. 12, 1925.
15. Type 30-A shearing-drilling machine; 50-hp. motor, 250-500 volts, D. C. Approvals No. 125 and 125A, issued April 26, 1926 to The Jeffrey Mfg. Co.
16. Type CLU cutting-shearing machine; 30-hp. motor, 250-500 volts, D. C. Approvals No. 134 and 134A, issued to the Sullivan Machinery Co., March 18, 1927.
17. Type CLE longwall mining machine; 30-hp. motor, 250-500 volts, D. C. Approvals No. 136 and 136A, issued to the Sullivan Machinery Co., May 28, 1927.



Room Hoists

1. Oaks safety room hoist; 5-hp. motor, 250-500 volts, D. C. Approval No. 116 and 116A, issued to South Fork Foundry & Machine Co., Feb. 13, 1925.

Mine Pumps

1. Dravo-Doyle mine pump; Type Austin 5 x 6, 5-hp. General Electric motor and control, 500 volts, D. C. Approval No. 121-A, issued to Dravo-Doyle Co., Oct. 1, 1925.
2. Dravo-Doyle mine pump; Type Austin 5 x 6, 5-hp. Westinghouse motor and control, 250-500 volts, D. C. Approvals No. 124 and 124A, issued to Dravo-Doyle Co., April 14, 1926.

Rock-Dusting Machines

1. Mine Safety Appliances Co., rock-dusting machine; Westinghouse 5-hp., 230-volt motor and control, Mancha headlight. Approval No. 130, issued to Mine Safety Appliances Co., November 5, 1926.
2. Diamond Machine Co., rock-dusting machine; Jeffrey 15-hp., 230-volt motor and control. Approval No. 131, issued to Diamond Machine Co., December 28, 1926.
3. Mine Safety Appliances Co., rock-dusting machine, Jeffrey 15-hp. 230-volt motor and control, Mancha headlight. Approval No. 137 issued to Mine Safety Appliances Co., July 2, 1927.

Permissible Electric Switches and Junction Boxes Approved  
Under Schedule 4A.

1. Enclosed two-pole fused switch - 100 amperes, 500 volts, D. C. Approval No. 400A issued to Ohio Brass Co., August 5, 1925.
2. Enclosed two-pole fused switch - 250 amperes, 250 volts; 150 amperes, 500 volts, D. C. Approvals No. 401 and 401A issued to the Sullivan Machinery Co., May 11, 1927.
3. Enclosed 3-pole fused switch - 250 amperes, 220 volts; 150 amperes, 440 volts, A. C. Approvals No. 402 and 402A issued to the Sullivan Machinery Co., May 11, 1927.

PERMISSIBLE ELECTRIC CAP LAMPS FOR MINERS

Approved Under Schedule 6A

1. Edison Model "C" lamp. Approval No. 10, issued to Edison Storage Battery Co., Feb. 24, 1915.

2. Wico lamp, Approval No. 14, issued to Witherbee Igniter Co., June 10, 1916.
3. Wheat lamp. Approval No. 17, issued to Koehler Mfg. Co., Inc., Sept. 23, 1919.
4. Edison Model "E" lamp. Approval No. 18, issued to Edison Storage Battery Co., March 28, 1923.
5. RM-6 f. d. Ceag lamp. Approval No. 19, issued to Concordia Electric Co., Aug. 2, 1923.
6. Super-Wheat lamp. Approval No. 20, issued to Koehler Mfg. Co., Inc., Apr. 27, 1926.
7. RM-7 Ceag lamp. Approval No. 21, issued to Concordia Elec. Co., June 18, 1926.

#### PERMISSIBLE FLAME SAFETY LAMPS

Approved under Schedules 7, 7A and 7B.

1. Koehler steel frame lamp, flat wick. Approval No. 201, issued to Koehler Mfg. Co., Inc., Aug. 21, 1915.
2. Koehler steel frame lamp, round wick. Approval No. 201A, issued to Koehler Mfg. Co., Inc., July 29, 1918.
3. Koehler Aluminum frame lamp, flat wick. Approval No. 203, issued to Koehler Mfg. Co., Inc., Feb. 7, 1919.
4. Koehler Aluminum frame lamp, round wick. Approval No. 203A, issued to Koehler Mfg. Co., Inc., Feb. 7, 1919.
5. Wolf brass frame lamp, round wick. Approval No. 204, issued to Wolf Safety Lamp Co. of America, Inc., July 18, 1921.
6. Wolf Aluminum frame lamp, round wick. Approval No. 205, issued to Wolf Safety Lamp Co. of America, Inc., Apr. 24, 1924.
7. Wolf Aluminum frame lamp, flat wick. Approval No. 206, issued to Wolf Safety Lamp Co. of America, Inc., Apr. 24, 1924.
8. Wolf brass frame lamp, flat wick. Approval No. 207, issued to Wolf Safety Lamp Co. of America, Inc., March 14, 1927.

#### Permissible Electric Hand and Trip Lamps Approved Under Schedule 10A

1. Type RMC-RMCT Ceag hand and trip lamp. Approval No. 1000, issued to Concordia Electric Co., May 25, 1922.
2. Model "E" inspection lamp. Approval No. 1001, issued to Mine Safety Appliances Co., July 28, 1925.



Permissible Electric Flash Lamps Approved Under Schedule 11.

1. Eveready, safety type, flash lamp. Approval No. 301, issued to National Carbon Co., Inc., Oct. 22, 1924.

PERMISSIBLE METHANE INDICATORS AND DETECTORS

Approved Under Schedules 7B and 8A

Methane Indicators

1. Burrell indicator. Approval No. 800 issued to Mine Safety Appliances Company, March 10, 1922.

Methane Detectors

1. Wolf flame-type detector. Approval No. 207, issued to Wolf Safety Lamp Co. of America, Inc., Nov. 21, 1924.

PERMISSIBLE SINGLE-SHOT BLASTING UNITS

Approved Under Schedule 12

1. Attachment for Edison M-8 mine lamp battery. Approval No. 1200, issued to Mine Safety Appliances Co., May 24, 1920.
2. Davis No. 0 magneto-type blaster. Approval 1201, issued to Davis Instrument Mfg. Co., (Inc.) Mar. 15, 1921.
3. Du Pont pocket magneto type blaster. Approval No. 1202, issued to E. I. Du Pont de Nemours & Co., Aug. 15, 1924.
4. Davis No. 00 magneto-type blaster. Approval No. 1203, issued to Davis Instrument Mfg. Co. (Inc.) Oct. 17, 1924.
5. Attachment of Concordia Type RM-6 f.d. mine lamp battery. Approval No. 1204, issued to the Concordia Electric Co., Mar. 2, 1925.
6. Attachment for Edison Model "E" lamp battery. Approval No. 1205, issued to the Mine Safety Appliances Co., April 28, 1925.
7. Eveready dry cell blaster. Approval No. 1206, issued to National Carbon Co., (Inc.) Aug. 20, 1925.
8. Davis No. 000 magneto-type blaster. Approval No. 1207 issued to Davis Instrument Manufacturing Co., Inc., Nov. 18, 1926.

# PERMISSIBLE STORAGE BATTERY LOCOMOTIVES AND POWER TRUCKS

## Approved Under Schedule 15

### Gathering Locomotives

1. Whitcomb E.S.B. flame-proof locomotive. Approval No. 1500, issued to Geo. D. Whitcomb Co., Mar. 14, 1921. The following batteries are optional\*: 80 cells Edison G-14, 96 cells Edison A-10, 48 cells Gould, 29 plate.
2. Jeffrey type B.D.M. class 40 locomotive. Approval No. 1501, issued to the Jeffrey Manufacturing Co., October 11, 1921. The following batteries are optional\*: 80 cells, Edison A-12, 88 cells Edison A-12, 104 cells Edison A-12, 49 cells Phila. 33 plate, 48 cells Exide 21 plate, 80 cells Edison A-8.
3. Mancha flame-proof "Hercules" locomotive. Approval No. 1502, issued to the Mancha Storage Battery Locomotive Co., Nov. 13, 1922. The following batteries are optional\*: 48 cells Phila. 33 plate, 48 cells Phila. 39 plate, 48 cells Gould 33 plate, 48 cells Exide 27 plate.
4. Iron-ton type W.O.G. locomotive. Approval No. 1503, issued to Iron-ton Engine Co., Mar. 24, 1923. The following batteries are optional\*: 88 cells Edison A-10, 49 cells Phila. 33 plate, 48 cells Phila. 33 plate.
5. Goodman articulated type locomotive. Approval No. 1504, issued to Goodman Mfg. Co., July 10, 1923. Battery, 134 cells Edison A-8.
6. Mancha Hercules A and AX locomotives. Approval No. 1505, issued to the Mancha Storage Battery Locomotive Co., April 5, 1924. The following batteries are optional\*: 54 cells 33 plate Exide, 54 cells Phila. 39 plate, 90 cells Edison A-12, 92 cells Edison A-10.
7. Jeffrey type B.D.M. Class 25 locomotive. Approval No. 1507, re-issued to The Jeffrey Mfg. Co., Aug. 20, 1925. The following batteries are optional\*: 54 cells 33 plate Exide, 54 cells Phila. 39 plate, 54 cells Phila. 33 plate, 48 cells KW 37 plate.
8. Goodman Type 10-30 locomotive. Approval No. 1508, issued to the Goodman Mfg. Co., Mar. 21, 1925. The following batteries are optional\*: 48 cells Exide 33 plate, 48 cells Phila. 39 plate.
9. Goodman Type 8-30 locomotive. Approval No. 1509, issued to the Goodman Mfg. Co., Sept. 25, 1925. Battery 48 cells Exide 23 plate.
10. Mancha Standard A and AX locomotives. Approval No. 1511, issued to Mancha Storage Battery Locomotive Co., Nov. 10, 1925. The following batteries are optional\*: 48 cells Phila. 23 plate, 48 cells Phila. 29 plate, 49 cells Phila. 29 plate; 48 cells Exide 19 plate; 48 cells Exide 23 plate.

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\* This includes all batteries covered by the original approval or extensions of approval prior to July 1, 1927.



11. Westinghouse-Baldwin locomotive. Approval No. 1512, issued to Westinghouse Electric & Mfg. Co., Nov. 11, 1925. The following batteries are optional:\* 80 cells Edison A-8; 48 cells Exide 19 plate; 48 cells Exide 27 plate.
12. General Electric type LSBE-206-C9 locomotive. Approval No. 1513, issued to General Electric Co., February 25, 1926. The following batteries are optional:\* 48 cells Exide 27 plate, 80 cells Edison A-12; 48 cells Exide 33 plate.
13. Jeffrey Type B.D.M. 25 Form H Locomotive. Approval No. 1516, issued to The Jeffrey Mfg. Co., December 28, 1926. Battery, 48 cells Exide 33 plate.
14. Atlas Type B locomotive. Approval No. 1517, issued to Atlas Car & Mfg. Co., Feb. 10, 1927. Battery 48 cells Phila. 39 plate.

#### Main Line Haulage Locomotive

1. Jeffrey Type B.D.M. Class 30 main line haulage locomotive. Approval No. 1510, issued to Jeffrey Mfg. Co., Oct. 12, 1925. The following batteries are optional:\* 110 cells Phila. 39 plate, 110 cells Exide 33 plate.

#### Power Trucks

1. Mancha power tank. Approval No. 1506, issued to Mancha Storage Battery Locomotive Co., May 5, 1924. The following batteries are optional:\* 110 cells Phila. 29 plate, 110 cells Phila. 31 plate, 117 cells Phila. 27 plate, 110 cells Exide 27 plate, 117 cells Exide 23 plate.
2. Mancha power tank and gathering locomotive. Approval No. 1505A, issued to Mancha Storage Battery Locomotive Co., June 21, 1926. Battery 117 cells Phila. 19 plate.
3. Jeffrey power truck and main line haulage locomotive. Approval No. 1510-C, issued to The Jeffrey Manufacturing Co., Dec. 31, 1926. Battery 117 cells Phila. 39 plate.
4. Mancha non-propelled power truck, Approval No. 1514, issued to Mancha Storage Battery Locomotive Co., December 18, 1926. The following batteries are optional:\* 110 cells 27 plate Exide, 117 cells 23 plate Exide, 110 cells Phila. 31 plate, 117 cells Phila. 27 plate.
5. Jeffrey Power truck. Approval No. 1515, issued to The Jeffrey Mfg. Co., December 28, 1926. Battery 117 cells Phila. 27 plate.

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\* This includes all batteries covered by the original approval or extensions of approval prior to July 1, 1927.

PERMISSIBLE SELF CONTAINED OXYGEN BREATHING APPARATUS AND GAS MASKS.

Approved Under Schedules 13 and 14A

Oxygen Breathing Apparatus

1. Gibbs mine rescue breathing apparatus. Approval No. 1300, issued to Mine Safety Appliances Co., January 15, 1920.
2. Paul mine rescue breathing apparatus. Approval No. 1301, issued to American Atmos Corp., January 15, 1920.
3. Fleuss-Davis Proto apparatus. Approval No. 1302, issued to Siebe, Gorman and Co., (Ltd.) February 7, 1924.
4. McCaa mine rescue breathing apparatus. Approval No. 1303, issued to Mine Safety Appliances Co., Aug. 31, 1925.

Gas Masks

1. Burrell ammonia gas mask. Approval No. 1401, issued to Mine Safety Appliances Co., April 10, 1920.
2. M. S. A. self-rescuer. Approval No. 1402, issued to Mine Safety Appliances Co., March 6, 1924.
3. All-service gas mask. Approval No. 1403, issued to Mine Safety Appliances Co., July 1, 1925.
4. G. M. D. ammonia gas mask. Approval No. 1404, issued to Mine Safety Appliances Co., March 10, 1926.
5. La France ammonia gas mask. Approval No. 1401, issued to American La France Fire Engine Co., Inc., June 23, 1927.

Information Circular, Bureau of Mines, Department of Commerce.





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September, 1927.

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INSTRUCTIONS FOR SAMPLING ATMOSPHERIC DUST  
BY THE IMPINGER METHOD. 1

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THE APPARATUS

The apparatus for sampling atmospheric dusts, as developed in the laboratories of the Bureau of Mines,<sup>3</sup> consists of a collapsible stand carrying a portable, hand-operated suction pump connected by means of rubber tubing to the impinging device inserted in a sampling bottle. (See Figure 1.)

Suction is supplied by a small rotary-vane pump made as light as possible. This should be calibrated at intervals against an accurate gas meter to obtain the ratio between the number of revolutions per minute and the number of cubic feet of air drawn through the apparatus. The practice has been to use that rate of speed which will draw 1 cubic foot of air a minute against the resistance of the impinger adjusted as described later.

The impinging device (see Figure 2) consists of a 1/2-inch glass tube, 8 inches in length, drawn down sharply at one end to an orifice 2.3 millimeters in diameter. A 1-inch bronze disc is supported 5 millimeters from the end of this tube. The whole device is inserted in a 2-hole rubber stopper, in the other opening of which is a short glass tube of the same diameter connected to the suction pump with a rubber hose. A 16-oz. wide-mouth laboratory bottle taking a No. 8 or 9 rubber stopper is used. In this 150 to 200 c.c. of liquid is placed and the impinger inserted, extending nearly to the bottom. When suction is applied, the dust-laden air is drawn in through the glass tube, the dust impinges on the wet brass plate at the bottom at high velocity and floats off in suspension in the surrounding liquid.

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- 1 - Published with approval of the Director, U. S. Bureau of Mines.
  - 2 - Associate geologist, Pittsburgh Experiment Station.
  - 3 - Katz, S. H., Smith, G. W., Myers, W. M., Trostel, L. J., Ingels, M., and Greenburg, L., Comparative Tests of Instruments for Determining Atmospheric Dusts. Public Health Bull. 144, 1925, pp. 62-69.



## SAMPLING

Preparation of Apparatus

Care should always be taken to see that the impinger pump is in good mechanical condition before sampling. Small defects will considerably increase the effort expended. It is therefore advisable in preparation for field work to take the pump apart and carefully clean it with some solvent such as gasoline or benzene, which will remove all dirty oil. After assembly, the parts should be adjusted until the pump operates smoothly. A light machine oil should be used after cleaning and frequently during use.

Calibration

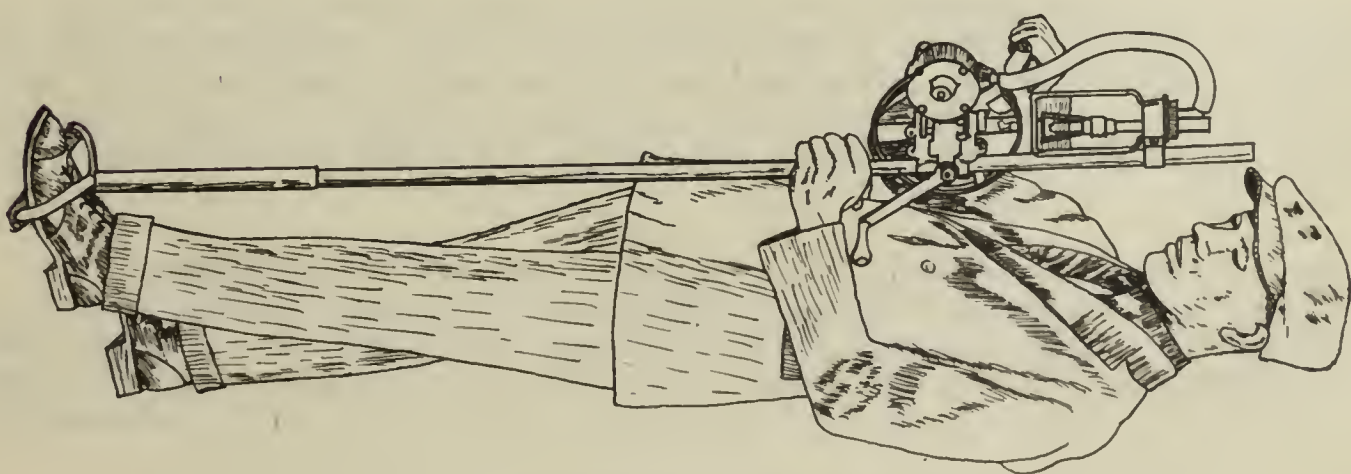
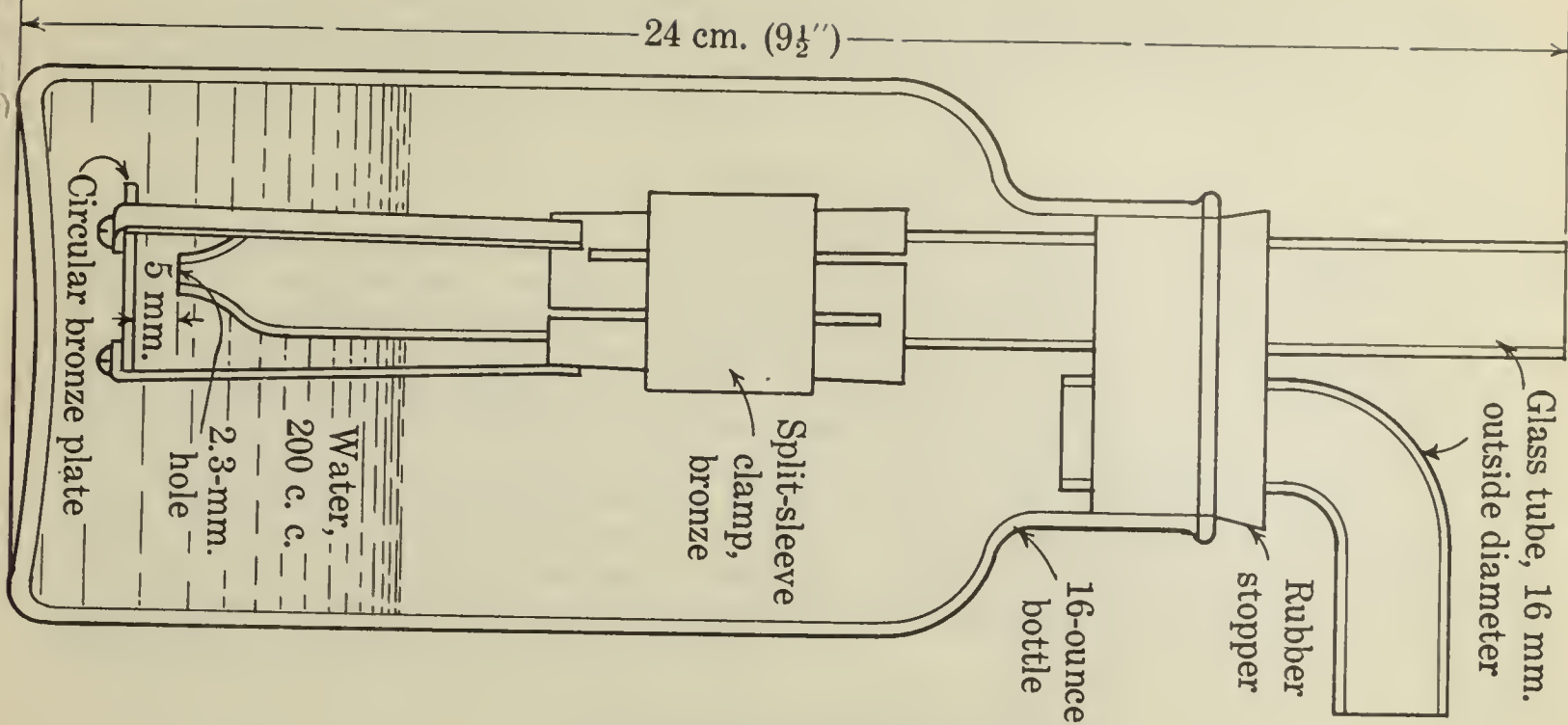
After such overhauling, a new calibration curve should be made. The accuracy of the gas meter selected as a standard will control the accuracy of the calibration. It is suggested that a 5 light, dry, test meter for gases be used. This is attached to the intake side of the impinger (which contains the usual amount of collecting liquid). It is then calibrated at different rates of rotation in order to ascertain the speed (usually about 80 r.p.m. of the handles) required to draw one cubic foot of gas per minute. The time for each speed should be accurately noted and the results plotted. From these data it can easily be determined at what speed the pump must be operated to draw the desired amount of air at the determined rate.

Solubility of Certain Dusts

Many so-called insoluble substances are dissolved by water or other solvents to such a slight extent as to be entirely unnoticeable in most cases. However, in the collection of atmospheric dusts one is usually dealing with exceedingly small amounts of material so that even this slight effect introduces a large percentage of error. Furthermore, the great amount of surface presented by the extremely fine air-floated particles increases the rate of solution. For these reasons, great care must be used in the selection of the proper liquid for sampling. Quartz, for example, although ordinarily regarded as water-insoluble, dissolves to an extent prohibitive of the use of water as the collecting medium for dusts in which it may be present. For the same reason, water is also unsatisfactory in collecting most mineral dusts. Experimentation<sup>4</sup> has shown that alcohol is the best liquid to use for collecting these materials.

On the other hand, organic matter is likely to be dissolved by alcohol or similar solvents to a degree which makes its use unsatisfactory in the collection of organic dusts. Certain constituents of coal, for example, are slightly soluble in alcohol. On the other hand, these are insoluble in water, but water is an inefficient collecting medium, probably because it will not wet the dust. The addition of water to alcohol greatly reduces any solubility effect, whereas, alcohol-water mixtures will wet and collect coal. For this reason, a mixture of 20 to 25 per cent of alcohol and 75 to 80 per cent of water is customarily used in sampling atmospheric dust in coal mines.

4 - Myers, W. M., Solubility of Finely Divided Rock-Dusts in Water, Kerosene, and Alcohol. Bureau of Mines, Repts. of Investigations, Serial No. 2548, Nov. 1923, 6 pp.







Owing to the various solubility effects possible when dealing with mixed dusts, no matter how great care has been observed in the selection of the liquid medium, samples should be sent promptly to the laboratory and analyzed as soon as possible.

### Bottle Stoppers

Rubber stoppers have been found to prevent leakage from the sample bottles better than any others. However, alcohol exerts a solvent action on them. The addition of water during analysis to solutions which have been in contact with rubber stoppers precipitates clouds of finely divided material which renders a dust sample valueless. Stoppers boiled in 5 per cent caustic hydroxide solution for several days and then placed in alcohol and boiled (using a flask with reflux condenser) for several days are satisfactory if care is taken in storage to keep the bottles right side up, and so prevent contact between the alcohol and the rubber. In other words, the treatment removes sufficient alcohol-soluble material to make the effect of contact during shipment negligible. When not in use, stoppers may be advantageously stored in a large flask of alcohol kept for that purpose.

### Preparation of Sample Bottles

As the purpose of this kind of sampling is to detect and quantitatively measure the kind, size, and amount of atmospheric dust, the presence of any solid matter in the original sampling solution is extremely deleterious. Great care should be employed in preparing the bottles and the solutions and in filling and sealing the tubes for shipment. Distilled water to be used should be allowed to settle for one day before syphoning. Alcohol should be re-distilled if possible. In the field similar extreme caution should be exercised in handling the sample bottle to exclude dust other than that quantitatively sampled.

Ordinary friction tape is the most satisfactory material for sealing bottles for shipment. After driving the stopper tightly in place, a length of tape is put securely around the bottle lengthwise, starting at the bottom, going over the stopper, down the other side, and around again. A short piece is then wound snugly around the neck, pulling the vertical piece tighter and holding it firmly.

Samples can be shipped to and from the laboratory either in individual cardboard cartons with metal screw tops or packed in larger boxes containing many samples. The containers should be large enough to allow the insertion of paper or waste packing below, around and above the bottles, and should be labeled as fragile.

### Selection of Sampling Points

The selection of the point of sampling is important. In general, each sample should be planned to give some definite piece of information or data pertinent to the study or investigation. If the purpose is to determine the dust breathed by a man under definite working conditions, the sample bottle, equipped with an extension hose, should be held by an assistant as near the nose of the



worker as possible. If it is in a ventilation current the bottle should be moved about to traverse the entire cross section. If information is desired regarding the dust raised by some single operation, caution should be exercised to see that no other operations affect the dust produced. For example, a sample collected in a mine during dry drilling alone means more for comparison than one taken while men are drilling both wet and dry or with ore being shoveled in the vicinity. In any case, a full report of the conditions surrounding the collection of the sample should be reported to the laboratory.

### Collection of Samples

As a rule, it is easier to carry the impinger pump assembled for use than in the dismantled form in which it is shipped. When ready to take a sample, the bottle is unsealed, the stopper removed, the impinging device inserted, and connected to the pump, and the whole clamped to the stand if so desired. All is now ready for sampling. Care should be taken in the preceding steps to prevent contamination of the sampling solution with dust. Bottles should never be allowed to stand open; the impinger should be carefully protected from dust between different samples and the shipping stoppers should be similarly guarded during collection.

The impinging device should be carried in a spare bottle containing the same solution used for sampling. This acts as a rinse for the impinger between samples. While the impinger is in use, the stopper from the sample bottle may be put in this rinse bottle, thus protecting the solution and the stopper from external dust. The rinse should be renewed as soon as contaminated with dust, probably at least once a day unless samples are collected in almost dust-free air, under which conditions it could be used again, or unless collection is done in extremely dust air, which would necessitate more frequent change of rinse.

The period of sampling varies in relation to the concentration of dust in the atmosphere; 15 minutes is necessary for ordinary dusty air. The more dust present the shorter the sampling period, and the lower the concentration the longer the sampling period. The correct balance between concentration and period of sampling can only be obtained by experience.

If the evaporation of the collecting liquid is excessive and reduces the amount  $1/4$  to  $1/3$  (likely to happen only when alcohol is the liquid medium and sampling is continued over long periods) more solution can be added from another bottle to restore the amount to normal.

After sampling, the impinger should be removed from the bottle, first agitating in the liquid to prevent dust from adhering to the tubes. This movement of the liquid can be induced by shaking and if necessary, gentle blowing through the dust intake side of the impinger. The stopper is quickly inserted and the bottle sealed and packed for return to the laboratory.

Bottles should be shipped promptly to the laboratory. All the information available in regard to the conditions under which samples were collected should be submitted at the same time. Prompt shipment lessens danger from deterioration (mainly through solubility) and gives the laboratory more time to arrange for making analysis in event other work is in progress.

### Stoppers in Pump Tubes to Keep Out Foreign Material

After sampling and before going to the next place of collection, small stoppers should be inserted in the intake and outlet tubes of the pump to prevent solid particles from getting into the blower. More trouble has been experienced in the past from such fragments falling into one of the openings or being picked up when the instrument has been laid or fallen against dirty walls or on dirty floors than from all other causes. These plugs should not be removed until just before sampling.

### Recording Conditions

Careful records should be taken immediately after collecting each sample to include all pertinent data. It is almost impossible to obtain too much specific information regarding the conditions in the place of sampling and general information of the mine or factory as a whole. Results are often vitiated through lack of good data.

The form following is used by the Bureau of Mines in collecting atmospheric dust samples in coal mines and shows the type of information which should be taken.



(Front)

Department of Commerce  
Bureau of Mines

Atmospheric Dust: Coal Mines

Container No. \_\_\_\_\_

Lab. No. \_\_\_\_\_

				Section Coal Bed	
Sample of _____		(a)			
Mine _____		Operator _____			
State _____		County _____		Bed _____	
Town _____					
		(Distance and direction from)			
Use of water in mine _____		(b)			
(Yes					
Rock dusted: (No Extent _____		(c)		Condition _____ (c)	
				Material _____ (c)	
Location in mine _____				Operation proceeding _____	
Moisture _____ (d)		Method sampling _____ (e)		Volume air _____ (f)	
				Time start _____ (g)	
Settled dust: Rib _____ (h)		Roof _____ (h)		Floor _____ (h)	
				Track _____ (h)	
Date sampled _____		Mailed _____		Received _____	
				Collector _____	

(Back)

LOCATION: Distance from: Face \_\_\_\_\_ Rib \_\_\_\_\_ Floor \_\_\_\_\_ Last open crosscut \_\_\_\_\_  
Width \_\_\_\_\_ Rooms: Depth \_\_\_\_\_ Air: Movement \_\_\_\_\_ (i) Quantity last crosscut \_\_\_\_\_  
Entries: Air: Velocity \_\_\_\_\_ Quantity \_\_\_\_\_ Intake or return \_\_\_\_\_  
OPERATION: No. men in place \_\_\_\_\_ Working \_\_\_\_\_ Time: Working \_\_\_\_\_ (j) Resting \_\_\_\_\_ (j)  
Type and make of machine \_\_\_\_\_ Material: Kind \_\_\_\_\_ (k) Size \_\_\_\_\_ (k) Moisture \_\_\_\_\_ (k)  
Use of water \_\_\_\_\_ (l) Quantity \_\_\_\_\_ (m)  
Undercutting: Depth cut \_\_\_\_\_ Kerf \_\_\_\_\_ Length cut \_\_\_\_\_ Time: Sump \_\_\_\_\_ Cut \_\_\_\_\_  
No. scrapers \_\_\_\_\_ Condition bits \_\_\_\_\_ Cuttings: Dry \_\_\_\_\_ Damp \_\_\_\_\_ Wet \_\_\_\_\_  
(and)  
Loading (or ) Conveying: No. handlings material \_\_\_\_\_ Size car \_\_\_\_\_ No. loaded \_\_\_\_\_  
Drilling: Upper \_\_\_\_\_ Horizontal \_\_\_\_\_ Down \_\_\_\_\_ Angle \_\_\_\_\_ Depth \_\_\_\_\_ Diameter \_\_\_\_\_  
Hauling: Type \_\_\_\_\_ (n) Speed \_\_\_\_\_ Track: Curve or straight \_\_\_\_\_ Ballasted \_\_\_\_\_  
Car: Tight or endgate \_\_\_\_\_ Size \_\_\_\_\_ Repair \_\_\_\_\_ Topping \_\_\_\_\_ Spillage \_\_\_\_\_  
Empties: No. trips \_\_\_\_\_ Cars per trip \_\_\_\_\_ Loads: No. trips \_\_\_\_\_ Cars per trip \_\_\_\_\_  
Remarks: \_\_\_\_\_

The information requested on the front of the card is, with few exceptions, general in nature; that on the back is specific. For most of the blanks the information desired is obvious. Legitimate questions may arise in the sampler's mind, however, over others. The blanks in which there might be doubt have been lettered and will be briefly explained.

Although this card is for use exclusively in coal mines, dusts of different compositions are there raised by such operations as mining coal, brushing roof, picking floor, rock-dusting, etc. For this reason mention should be made

on the first line, marked (a), regarding the kind of atmospheric dust sampled, whether coal, shale, sandstone, limestone, adobe, or mixed dust.

The use of water is important as affecting the amount of dust raised.<sup>5</sup> Not only is it necessary to know what use is made of water in the particular operation proceeding during sampling, blank (l), but it is valuable to know what general use is made of it throughout the mine, blank (b), as affecting the amount of dust carried by air currents. Hence, although blanks (b) and (l) both request information in regard to the use of water, they differ materially in the answers desired.

The rock-dust now being applied in many mines influences both the amount and composition of atmospheric dust. Information regarding the material used aids in the consideration of the composition, while information as to the extent of rock-dusting, whether main entries, to the face, or other methods, and its condition, fresh, exhausted, or intermediate stages, intimately affect the amount. This information should be given in blank (c).

What is the effect of moisture on the amount of dust produced? Correlation can be attempted if blank (d) is filled.

There are many ways by which dust can be sampled from air, each with its own relative efficiency.<sup>6</sup> A knowledge of the method used, blank (e), assists in an interpretation of the results.

In order to have a standard of comparison, the figures are calculated as amount of dust per unit of volume. It is therefore necessary to record the volume of air from which the dust was sampled, blank (f).

Dustiness might vary during the day. To assist in possible correlation along this line blank (g) should be filled.

Settled dust may be raised by passing air currents. Apparently abnormal results may sometimes be explained if the amount and kind of dust settled on the ribs, roof, and floor are known. Such data should be given in blank (h), concisely by some such statements as "much coal," "none," "little limestone," etc.

There are two main headings on the back of the card, location and operation, under both of which certain general and specific information is desired. The general data under each of these should always be filled in. In addition, at least one specific subhead ought to be completed. For "Location," either the questions labeled "Rooms" or those labeled "Entries" should be answered, depending on whether the sample was collected in a room or entry. Under "Operation," specific data should be added under the proper heading for the work being performed. If the men are engaged in but one type of labor, only one subhead need be filled. On the other hand, if several operations are proceeding simultaneously attention should be given to each of the subdivisions covering the operations proceeding.

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5 - Forbes, J. J., and Emery, Alden H., Sources of Dust in Coal Mines. Bureau of Mines, Reports of Investigations, Serial No. 2793, February, 1927, 17 pp.

6 - See reference 3, pp. 47-62.



Whenever possible the velocity and air quantity should be given. It is often possible to detect movement of air when accurate measurement of quantity is impossible. This usually occurs in rooms, and in these cases a qualitative answer, such as "none," "good," "sufficient," etc., may be given in blank (i).

Blank (j) requests information on the time men work and rest during the collection of the samples. These data, of course, may be only an approximation, but they give some figures for correlation with the results.

Material other than coal may be handled in coal mines. Its composition is important as controlling the composition of the atmospheric dust. Its size, particularly in the case of coal where the range is from large lumps to dust, and its moisture content should be correlated with the quantity of dust raised. Blank (k) supplies opportunity for this information.

It will not always be possible to fill blank (m) which requests data on the quantity of water used in the particular operation proceeding. It is, however, one of the most valuable questions on the card when properly answered.

Under the type of haulage, blank (n), information is desired as to whether rope, mule, or motor furnish the motive power.

Forms similar to this may be drafted for all types of mines or industries where extensive sampling is contemplated. Where isolated samples only are taken, similar information should be obtained even without a definite system of blanks to be completed.

## LABORATORY TECHNIQUE<sup>7</sup>

Large particles of dusts settle quickly and so are a factor in atmospheric suspensoids for only a short time. Their physiological effect, too, can usually be disregarded. Consequently, the first step in the laboratory handling of these dusts is to filter the suspension into a 500-c.c. volumetric flask through a metal funnel supporting a 280-mesh screen, which removes all particles over 50 microns in diameter, then washing and making up to volume.

### Counting the Particles

In order to ascertain the number of particles in the sample, it is thoroughly shaken and 1 c.c. placed in a small counting cell holding exactly that amount of liquid. After the dust has settled (15 to 30 minutes), the number of fragments in numerous fields under a calibrated microscope are counted. At least 5 fields, one in the middle and one at each corner of the cell, should be counted and averaged. If one is interested in particles of different size ranges, a visual separation may be made and recorded. The common practice in the Bureau of Mines is to record those above and those below 10 microns separately. When the volume represented by each field is known, it is easy to calculate the number of particles in the total cell and hence in the whole 500-c.c. sample. These results are reduced and expressed in millions of particles per cubic meter of air sampled.

<sup>7</sup> - For more complete data on the laboratory technique see Selvig, W. A., Osgood, F. D., and Fieldner, A. C., Collection and Examination of Rock Dust in Mine Air. Bureau of Mines, Reports of Investigations Serial No. 2122, 1920.

## Separating the Sizes

The next step is to separate the fragments in suspension into whatever size ranges may be desired, usually those above and those below 10 microns in diameter. This is done by sedimentation. The 500-c.c. suspension is poured into a tall 800-c.c. beaker and rinsings are added to bring it to 10 cm. in depth. This is allowed to stand for a definite period, calculated from the specific gravity and size of the dust fragments and the density and viscosity of the suspending medium.<sup>8</sup> At the end of this time, the supernatant liquid, with what particles may remain in suspension, is siphoned into another beaker. Those particles which have settled out are agitated and completely mixed with enough water to fill the beaker to half the depth first used and allowed to stand for a calculated period, depending again on the same factors of density and viscosity. At the end of this period, it is again siphoned; the liquid is added to the first siphoning, which now contains the particles less than 10 microns in size, and that which remains in the original beaker contains the larger fragments. These portions are now filtered separately.

In case the dust is an incombustible one, the filter papers may be ignited in weighed crucibles and the quantity of dust in the two portions thus determined. If the dust is combustible, the filter papers must be dried and weighed before filtering, after which the process is repeated and the quantity of dust so obtained. Such drying of filter papers is difficult due to the hygroscopic nature of filter paper. It should therefore be carefully done by some standard method.<sup>9</sup> By calculation, these figures are reduced to milligrams of dust per cubic meter of air sampled. The four figures obtained--namely, millions of dust particles above and below a limiting size and milligrams of fragments for each group, together with their totals--give a reliable estimate of the amount of dust in the air at the time and place of sampling.-- Information Circular, Bureau of Mines, Department of Commerce.

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8 - Stokes law for the rate of precipitation of suspended spherical particles is used. This says that velocity of fall =

$$\frac{\text{Force}}{6 \pi \times \text{radius} \times \text{viscosity of solution}} \quad \text{or} \quad \frac{ds}{dt} = \frac{f}{6 \pi r \eta} \quad \text{where } s = \text{distance particle has fallen, } t = \text{time, and } \eta = \text{viscosity of solution.}$$

This can be reduced to  $t = \frac{6 \pi r \eta s}{f}$

9 - Katz, S. H. and Smith, G. W. Determination of Suspended Matter in Gases by Collection on Filter Paper. Bureau of Mines Reports of Investigations Serial No. 2378, July 1922, 6 pp.





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RAILROAD FUEL OIL CONSUMPTION IN 1926

By Arthur Huber Redfield 1

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This study of railroad fuel oil consumption in 1926 is a continuation of the study of Railroad Fuel Oil Consumption in 1925, by E. B. Swanson, published in January, 1927, as Information Circular 6017 of the Bureau of Mines

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Increased prices of fuel oil, especially in the South Central States, and increased efficiency in its utilization especially in California, Texas, and Louisiana, caused a slight and unimportant decrease in the consumption of fuel oil by United States railroads in 1926, as compared with 1925. Although the general consumption of fuel of all kinds by Class I railroads increased 0.53 per cent in 1926 over 1925, the quantity of fuel oil consumed by locomotives on Class I railroads decreased 0.33 per cent, and the fuel oil consumed by all railroads for which information is available decreased 0.9 per cent, from 69,461,119 barrels in 1925 to 68,836,850 barrels in 1926.

The principal decreases took place in the California district; in the South Central district; and in the Atlantic district. Railroad fuel oil consumption increased slightly in the Oregon-Washington district, and to an unimportant extent in the Rocky Mountain district.

During 1926, a total of 71,446,956 barrels of fuel oil was purchased by the 152 Class I, II, and III railroads included in this statement. Of the total amount purchased, 68,836,850 barrels was consumed, and 2,610,106 barrels added to the quantity in storage. Railroad stocks of fuel oil at the end of 1926 amounted to 16,541,845 barrels, as compared with 13,931,739 barrels at the beginning of the year. Of the total consumed, 59,329,690 barrels was burned as locomotive fuel, and 9,507,160 barrels was consumed in shops, power plants, ferry boats, and other uses than for firing locomotives.

Although each of the 152 railroads used some fuel oil in its operations, comparatively few used it in large quantities. Only two railroad systems purchased more than 5,000,000 barrels each; and these two consumed jointly nearly half the fuel oil burned by railroads in the United States. Only 6 railroads purchased

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between 2,000,000 and 5,000,000 barrels, 19 railroads between 500,000 and 2,000,000 barrels, 19 railroads between 100,000 and 500,000 barrels, and 8 railroads between 50,000 and 100,000 barrels, while 98 railroads purchased less than 50,000 barrels during the entire year.

As in 1925 more than four-fifths of the oil burned by railroads in the United States was consumed in the South Central States and in California. Railroads operating in these two regions consumed 56,458,246 barrels or 82 per cent of the 1926 total. A little over 8 per cent was consumed in Oregon and Washington, and a little over 6 per cent in the South Atlantic region. The remaining 4 per cent was consumed in the North Central States and in the area adjacent to the Wyoming and Montana oil fields.

## RAILROAD FUEL OIL PURCHASES, STOCKS, AND CONSUMPTION, 1926

In Barrels of 42 U. S. gallons.

District	Purchases	Beginning	Stocks End of Year	Change	Total Consumpt	
					1926	1925
California	27,377,704	4,032,190	7,367,553	3,335,363	24,042,341	24,563,663
Oregon-Washington	5,655,099**	406,489	465,770	59,281	5,595,818	5,291,603
Rocky Mountain	2,430,483	109,709	116,409	6,700	2,423,783	2,419,729
North Central	158,212	9,245	11,873	2,628	155,584	159,476
South Central	31,586,196	9,128,603	8,298,894	829,709*	32,415,905	32,674,904
Atlantic	4,239,262	245,503	281,346	35,843	4,203,419	4,351,744
	71,446,956	13,931,739	16,541,845	2,610,106	68,836,850	69,461,119

\* Represents stock decrease

\*\* Of this quantity 4,982,353 barrels was obtained from Montana and Wyoming; the remainder from California.

In the California district, which includes those railroads operating in or having their western terminal in California, and supplied with fuel oil from California, the consumption of fuel oil by railroads diminished 521,322 barrels or 2.3 per cent from 1925 to 1926. This decrease of over half a million barrels may be ascribed chiefly to economies effected by increased efficiency in locomotive firing and in shops on the two great railway systems which together consume 85 per cent of the fuel oil burned by railroads in California. Decreases in the amount of fuel oil consumed by some minor roads were more or less counterbalanced by increase in the amount consumed by others. As a result of California prices which averaged 20 per cent lower than in 1925, stocks increased 3,335,363 barrels during the year.

An average decrease of about 12 per cent in the price paid for Montana and Wyoming fuel oil by railroads operating in or having their western terminal in Oregon or Washington may be considered responsible for the increase of 304,215 barrels or about 5 3/4 per cent in the fuel oil consumed in the Oregon-Washington district in 1926 as compared with 1925. One of the railroads operating in this district converted a number of its locomotives from coal to oil burning.

Similarly a slight decrease in the price of fuel oil was reflected in a slightly increased consumption of fuel oil in the Rocky Mountain district. This includes those railroads, other than transcontinental railroads terminating in Oregon or Washington, which consume fuel oil on their Wyoming, Montana, or Dakota divisions.

The slight decrease in fuel oil consumption by railroads of central United States north of Kansas City and St. Louis and short-line roads operating in States bordering the Great Lakes, is probably a reflection of varied increases in the prices of Mid-Continent fuel oil averaging 10 per cent. In this district, however, the use of fuel oil is relatively unimportant; only two railroads in this district consumed more than 25,000 barrels of fuel oil in 1926, and these two account for more than half of the fuel oil burned in this district. Over 70 per cent of the fuel oil consumed in the North Central States is burned in repair shops, power plants, and for uses other than firing locomotives.

Next to California, the largest decrease in the consumption of fuel oil, 258,999 barrels or 0.79 per cent, was in the South Central States among those railroads which operate in the area south of Kansas City and St. Louis, east of Albuquerque and Santa Fe, and west of Montgomery, Nashville, and Louisville and obtain their fuel oil mainly from Texas, Oklahoma, Arkansas, and Louisiana. This is largely due to increases in the price of fuel oil which averaged 13 to 16 per cent among the principal buyers. In Kansas, Missouri, and Oklahoma, where coal was available at two-thirds the price paid in 1920, some oil-burning locomotives were laid up and others were converted from oil to coal. With the use of mechanical stokers and at the prices prevailing, the use of coal on one railroad effected a 25 per cent saving in the cost of hauling each 1,000 gross ton-miles<sup>2</sup> of freight. Other railroads in Kansas and Oklahoma experimented with the use of lignite and low-grade bituminous coal. However, some of the diminished consumption of fuel oil in the South Central States may be ascribed to continued economy in the use of fuel oil through increased efficiency in operation, especially by the larger consumers. Although the increased crude oil production in Oklahoma during the present year has lowered the price of fuel oil below the 1926 average, those railroads which increased their proportion of coal-burning locomotives in 1926 have not returned to the burning of oil in their converted locomotives.

Increased economies in consumption, rather than the unimportant increase in the contract price of fuel oil in the States bordering the Atlantic Ocean and east of the Appalachian Mountains may be considered responsible for the slight decrease in the consumption of fuel oil by the railroads in 1926 as compared with 1925. In these States, however, 88 per cent of the oil burned in locomotives was consumed by one railroad in the South Atlantic States which used imported fuel oil, and 9 per cent more by four other great railroad systems which burn chiefly coal. Fully 45 per cent of the fuel oil consumed by railroads in these States was used in power plants, shops, ferry boats, firing-up of coal-burning locomotives and the operation of oil-electric switching locomotives.

2. The term gross ton-miles includes the total weight in short tons of freight, cars, fuel and water, locomotive and tender, multiplied by the number of miles hauled.

From 15,577,670 barrels in 1906 the consumption of oil as a locomotive fuel has grown more than fourfold in 20 years. Although complete statistics of fuel oil burned by railroads prior to 1925 are not available, the Interstate Commerce Commission has compiled and published for a number of years the quantity of oil burned in locomotives operated by Class I railroads. This represented in 1926 about 85 per cent of the total oil consumed as railroad fuel, the remainder being burned in shops, power plants, and vessels, and in locomotives operated by Class II & III railroads. With these figures is a statement of the number of oil-burning locomotives in service on Class I railroads.

Fuel Oil Consumed by Locomotives (Class I Railroads Only)

Year	No. of Oil-Burning Locomotives	Barrels of Oil Consumed.
1908	2,354	16,889,100
1909	2,690	19,905,335
1910	2,981	23,817,346
1911	3,565	29,748,845
1912	4,052	33,605,598
1913	4,055	33,004,815
1914	4,140	31,093,266
1915	***	32,830,187
1916	***	38,208,516
1917	***	42,973,555
1918	***	39,022,785
1919	***	37,763,361
1920	***	45,944,539
1921	***	39,553,131
1922	***	43,523,737
1923	6,962	55,580,138
1924	7,373	58,949,912
1925	7,112	58,519,685
1926	7,304	58,329,579

\*\*\* Not available.

From a maximum of 10.87 per cent in 1924, the proportion of fuel oil burned by Class I railroads to the total amount of fuel consumed, decreased slightly in 1925 and 1926. In the following table the fuel oil consumed has been converted at the ratio commonly used by the railroads (168 gallons to a short ton) to the number of short tons (2,000 pounds) of bituminous coal which represent an equivalent heating value, without considering the relative operating efficiencies of the various fuels consumed.



Comparison of Oil with Other Fuels Consumed  
(Class I Railroads Only)

Year	Fuel Oil Converted to Fuel Equivalent in Short Tons of Bituminous Coal.	Total Short Tons of Fuel Consumed by Locomotives	Per Cent Oil to Total Fuel Consumed
1917	10,745,389	150,230,647	7.15
1918	9,755,696	146,122,455	6.58
1919	9,440,840	132,620,935	7.12
1920	11,486,125	151,405,712	7.53
1921	9,889,545	121,000,242	8.17
1922	10,831,697	127,213,543	8.55
1923	13,895,034	148,921,714	9.32
1924	14,737,480	135,617,520	10.67
1925	14,629,921	135,419,983	10.80
1926	14,562,395	136,132,965	10.71

From the foregoing figures no uniform national tendency either toward the conversion of coal-burning locomotives to oil burning or the reverse, can be deduced. The quantity of fuel oil used each year varies in each region with the relative costs of oil and coal, the volume of traffic, the adoption of oil burning by railroads previously burning coal or the reverse, and the efficiency of burning.

During 1926, eleven oil-electric locomotives were placed in service and one in April, 1927. The oil-electric locomotive comprises a generator and storage battery unit operated by a Diesel engine. Accordingly, on April 30, 1927, twelve 60-ton, 300-horsepower, and three 100-ton, 600-horsepower locomotives of this type were in use. Thirteen of these were in switching service in New York, Philadelphia, Chicago, and St. Paul; one in Utah copper mining operations; and one employed by a California lumber company. Four more oil-electric locomotives were under construction at the end of April, 1927, one 145-ton, 750 horsepower; two 100-ton, 600 horsepower, and one 60-ton, 300 horsepower locomotive.

Manufacturers are experimenting with the construction of larger, more powerful oil-electric locomotives. One company was building in May, 1927, an experimental 1,000 horsepower oil-electric locomotive, using a 6-cylinder, 4-cycle Diesel engine. A second manufacturer is working on a locomotive with a 12-cylinder, 4-cycle engine rated at 960 horsepower at 325 revolutions per minute. Three other companies are working on locomotives with a 6-cylinder, 4-cycle engine rated at 750 horsepower at 500 revolutions per minute. One railroad company has designed a new type of Diesel locomotive and is building three of these locomotives in its own shops.

The increasing efficiency with which oil is burned as a locomotive fuel is indicated by the following table which shows the unit consumption of oil, in freight and passenger service, by two of the principal oil-burning railroads.

Year	Pacific Coast Lines Southern Pacific		Southern Pacific Lines in Texas and Louisiana	
	Gallons of oil per		Gallons of oil per	
	1,000 Gross Ton- Miles <sup>3</sup> of Freight	Passenger Car Mile	1,000 Gross Ton- Miles <sup>3</sup> of Freight	Passenger Car Mile
1912	16.63	1.37	-----	-----
1913	15.96	1.27	-----	-----
1914	15.50	1.20	-----	-----
1915	14.62	1.21	-----	-----
1916	14.56	1.22	-----	-----
1917	14.61	1.19	-----	-----
1918	14.18	1.18	-----	-----
1919	13.16	1.10	-----	-----
1920	14.42	1.11	11.71	1.17
1921	13.10	1.09	11.63	1.09
1922	12.85	1.06	11.35	1.07
1923	12.42	1.05	10.85	1.05
1924	11.47	1.00	10.22	.95
1925	11.15	.99	10.53	.93
1926	11.94	.95	10.38	.88

3. See footnote 2.

Grateful acknowledgment is made of the courtesy of the railroads furnishing information as to their oil-burning practice and of the Interstate Commerce Commission and railroad and public utility commissions of California and Texas in permitting examination of the reports filed by the railroads. The aid given by the Bureau of Railway Economics in Washington in compiling the number of oil-burning locomotives in use from 1923 to 1926 and in furnishing other information is greatly appreciated. -- Information Circular, Bureau of Mines, Department of Commerce.

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STATE GEOLOGICAL SURVEY  
ILLINOIS

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

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SOURCES AND DISTRIBUTION OF MAJOR PETROLEUM PRODUCTS  
ATLANTIC COAST STATES - 1926.

By E. B. Swanson\*

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This analysis of the sources and distribution of petroleum and its major products in the Atlantic Coast states was prepared by the Bureau of Mines in cooperation with the American Petroleum Institute for the purpose of presenting certain fundamental statistics pertaining to the industry during 1926. Comparisons are made with similar information collected previously relating to 1925.

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During 1926, the area included in this report, consisting of the seventeen Atlantic Coast states and the District of Columbia, was dependent upon other domestic and foreign sources for 98.3 per cent of the crude oil put through the refineries located on the Atlantic seaboard; 47 per cent of the gasoline consumed, including exports, and 47.2 per cent of the gas oil and fuel oil delivered. Oil production in Western Pennsylvania and New York furnished 1.7 per cent of the crude oil refined. The output of Atlantic Coast and Appalachian refineries supplied 53.0 per cent of the gasoline and 52.8 per cent of the gas oil and fuel oil delivered.

Total runs to stills of domestic and foreign crude oil were 2,310,000 barrels larger than in 1925. This increase is a balance between a decrease of 3,253,000 barrels in the quantity of domestic crude oil refined and an increase of 5,563,000 barrels in the amount of foreign crude oil refined during 1926, as compared with 1925. Total Atlantic Coast receipts of domestic crude oil during 1926 were slightly larger than in 1925, being 103,056,000 barrels as compared with 102,738,000 barrels in 1925. The larger refinery runs of domestic crude oil in 1925 were due to the fact that 3,303,000 barrels were withdrawn from refinery storage during 1925 to augment the quantities received, while during 1926, 805,000 barrels were added to storage.

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\* Economic Analyst, Bureau of Mines.



Shipments of crude oil by tankers from Gulf Coast ports increased from 72,556,000 barrels in 1925 to 78,992,000 barrels in 1926, while receipts by pipeline decreased from 16,246,000 barrels in 1925 to 12,069,000 barrels in 1926. The pipeline receipts in 1926 from the Appalachian and Illinois fields were approximately equal to those of 1925, but pipeline receipts from the Mid-Continent fields decreased from 11,903,000 barrels in 1925 to 7,458,000 barrels in 1926. Tanker receipts of crude oil from California were 2,000,000 barrels less than in 1925. Total receipts of foreign crude oils, including topped crudes and other fuel oils increased from 50,763,000 barrels in 1925 to 52,492,000 barrels in 1926.

The following statement summarizes the receipts and distribution of domestic crude oil in the Atlantic Coast area during 1926:

DOMESTIC CRUDE OIL SUMMARY - ATLANTIC COAST - 1926

Receipts:-	Barrels	Per Cent
By tankers from Gulf Coast ports . . . . .	78,992,000	76.7
By pipelines -		
From Mid-Continent fields . . . . .	7,458,000	7.2
From Appalachian and Illinois . . . . .	4,611,000	4.5
By tankers from California ports . . . . .	<u>11,995,000</u>	<u>11.6</u>
Total Atlantic Coast receipts. . . . .	103,056,000	100.0
Distribution:-		
Run to stills. . . . .	101,347,000	98.3
Added to refinery storage. . . . .	805,000	.8
Burned as fuel . . . . .	770,000	.8
Exported . . . . .	111,000	.1
Balance. . . . .	<u>23,000</u>	<u>----</u>
Total distribution . . . . .	103,056,000	100.0

FOREIGN CRUDE AND FUEL OIL SUMMARY - ATLANTIC COAST - 1926

Receipts:-	Barrels
Total receipts crude, fuel oil and topped crudes . . . . .	52,492,000
Drawn from refinery storage. . . . .	<u>464,000</u>
Total. . . . .	52,956,000
Distribution:-	
Run to stills. . . . .	29,329,000
Burned as fuel . . . . .	<u>23,627,000</u>
Total. . . . .	52,956,000

As a result of the cooperation of all companies shipping crude oil from Gulf Coast to Atlantic Coast ports, it is possible for the Bureau to present a statement showing the monthly shipments, quantities in transit, and receipts of crude oil shipped from Gulf Coast ports to Atlantic Coast ports.

MOVEMENT OF CRUDE OIL FROM GULF COAST TO ATLANTIC PORTS, 1926\*  
(In barrels of 42 gallons)

1925	Shipped from Gulf ports	In transit	Received at Atlantic ports
December	-----	1,318,135	-----
1926			
January	5,785,411	1,907,411	5,196,135
February	4,326,057	360,253	5,873,215
March	5,363,300	1,820,579	4,502,874
April	6,477,093	1,501,803	6,195,869
May	6,489,186	1,542,916	6,648,073
June	7,470,796	1,275,101	7,538,611
July	7,543,233	1,141,853	7,676,481
August	7,278,720	1,914,696	6,505,877
September	5,890,536	1,097,230	6,708,002
October	7,757,064	1,361,143	6,993,151
November	7,054,196	1,016,909	7,893,430
December	<u>7,359,222</u>	<u>1,121,196</u>	<u>7,254,935</u>
Totals	73,794,714	-----	73,991,653

\* Compiled by J. W. Mashaw, San Francisco office, and A. H. Redfield, Washington office, Bureau of Mines.

GASOLINE PRODUCTION, RECEIPTS AND DISTRIBUTION

Production of gasoline by Atlantic Coast refineries advanced from 41,527,000 barrels in 1925 to 46,142,000 barrels in 1926, an increase of 4,615,000 barrels, or 11.1 per cent, over 1925. This percentage increase in refinery production of gasoline corresponded with an average increase of 13.6 per cent in gasoline consumption in the Atlantic Coast area. The increased gasoline production was due partially to the fact that 2,277,000 more barrels of domestic and foreign crude oil were run through the refineries in 1926 than in 1925 but more largely to the fact that more gasoline was produced from the crude oil in 1926 than in 1925. The average recovery of gasoline per barrel of crude oil refined in 1925 was 32.4 per cent, or 13.6 gallons, which was increased during 1926 to 35.3 per cent, or 14.8 gallons. The greater recovery during 1926 was due to the increased output of gasoline by "cracking." The out-

put of straight-run gasoline decreased from 61.1 per cent of the Atlantic Coast gasoline production during 1925 to 53.2 per cent in 1926, while the output of gasoline by "cracking" increased from 31.2 per cent in 1925 to 38.6 per cent in 1926. The use of natural-gas-gasoline accounted for 7.7 per cent of the 1925 output and 8.2 per cent of the 1926 output.

During 1925, the gasoline production of Atlantic Coast Refineries supplied 49.2 per cent of the total Atlantic Coast demand, including exports. Although production increased during 1926, it supplied a slightly smaller percentage of the total gasoline demand, 48.8 per cent.

The following table summarizes the sources and distribution of gasoline in the Atlantic Coast area:-

ATLANTIC COAST GASOLINE SUMMARY - 1926

Production and Receipts:-	Barrels	Per. Cent
Produced by Atlantic Coast refineries . . . . .	46,142,000	48.8
Received by tankers from Gulf Coast ports . . . .	33,443,000	35.4
Received by tankers from California ports . . . .	8,031,000	8.5
Received from foreign ports . . . . .	2,911,000	3.1
Shipped from Appalachian refineries . . . . .	3,306,000	3.5
Drawn from Atlantic Coast refinery stocks . . . .	654,000	.7
Total available for distribution. . . . .	94,487,000	100.0
Distribution:-		
Consumed in Atlantic Coast states . . . . .	86,128,000	91.2
Exported from Atlantic Coast districts. . . . .	7,489,000	7.9
Probable evaporative losses. . . . .	870,000	.9
Total distribution . . . . .	94,487,000	100.0

The quantity reported shipped from Appalachian refineries is a total representing tank car shipments from Appalachian refiners to points in the Atlantic Coast states, as reported to the Bureau of Mines. The probable evaporative loss is computed as 1/99th of the consumption in the Atlantic Coast states, or a loss of one per cent estimated as occurring between the refineries or terminals and final delivery at the service station to the consumer.

On the following page will be found a tabulation showing the motor vehicle registration and gasoline consumption by states for the Atlantic Coast area for 1925 and 1926. Information as to motor vehicle registration was obtained from the Bureau of Public Roads, Department of Agriculture. Information on gasoline consumption was obtained directly from state officials administering the motor fuels tax for all states except Massachusetts, New York,



MOTOR VEHICLE REGISTRATION AND GASOLINE CONSUMPTION - ATLANTIC COAST STATES

1925 - 1926

State	Total Motor Vehicle Registration 1925	Per Cent Increase	Gasoline Consumption 1925 (Barrels)	Per cent Increase
Maine	140,499	7.8	1,363,969	8.5
New Hampshire	81,498	9.2	820,025	13.5
Vermont	69,576	6.4	615,790	6.9
Massachusetts	646,153	6.8	8,000,000*	10.0
Rhode Island	101,756	8.8	1,305,933	14.7
Connecticut	250,669	5.0	2,910,245	10.0
New York	1,625,583	11.7	21,000,000*	10.0
New Jersey	580,554	12.2	6,300,000*	10.0
Pennsylvania	1,330,433	9.4	12,501,842	12.0
Delaware	40,140	11.7	426,692	11.4
Maryland	234,247	7.9	2,408,316	16.5
Dist. of Col.	103,082	8.2	1,067,343	13.8
Virginia	232,650	14.1	3,063,112	11.0
North Carolina	340,287	13.1	3,984,327	22.3
South Carolina	168,496	7.5	1,999,109	7.3
Georgia	248,093	12.3	3,304,813	12.1
Florida	286,388	40.2	4,715,059	44.8
Total	6,530,104	11.4	75,786,575	13.6

\* Estimated.

and New Jersey. The gasoline consumption in these three states, which had no gasoline tax in 1926, was estimated on the basis of available information.

GAS AND FUEL OIL DISTRIBUTION, ATLANTIC COAST STATES, 1926

Production of gas and fuel oil at Atlantic Coast refineries during 1926 totalled 59,972,000 barrels, an increase of 1,047,000 barrels over the 1925 production. The refinery production of gas and fuel oil supplied 51.5 per cent of the total quantity distributed and was augmented by 23,627,000 barrels of topped crude and fuel oil received from foreign ports; 18,301,000 barrels received from Gulf Coast ports; 12,266,000 barrels received from California; 1,584,000 barrels shipped from Appalachian refineries; and 770,000 barrels of domestic crude oil which was burned directly as fuel, or a total quantity of 116,520,000 barrels available for distribution for commercial and industrial fuel purposes. Of the total quantity available, 111,531,000 barrels were marketed in Atlantic Coast states; 1,876,000 barrels shipped to foreign countries; 861,000 barrels shipped to states other than on the Atlantic seaboard; 1,027,000 barrels added to the quantity held in storage at refineries; leaving a balance of 1,226,000 barrels, which includes losses in handling and additions to quantities held in storage at other points than refineries.

The production, receipts and distribution of gas and fuel oil in the Atlantic Coast area during 1926 are shown in the following table:

GAS AND FUEL OIL SUMMARY, ATLANTIC COAST, 1926

Production and Receipts:-	Barrels	Per Cent
Produced by Atlantic Coast refineries . . . . .	59,972,000	51.5
Received from foreign ports . . . . .	23,627,000	20.3
By tankers from Gulf Coast ports. . . . .	18,301,000	15.7
By tankers from California ports. . . . .	12,266,000	10.5
Shipped by Appalachian refineries . . . . .	1,584,000	1.3
Domestic crude oil burned as fuel . . . . .	770,000	.7
Total available for distribution. . . . .	116,520,000	100.0
Distribution:-		
Marketed in Atlantic Coast states . . . . .	111,530,000	95.7
Exported from Atlantic Coast districts. . . . .	1,876,000	1.6
Shipped to other states . . . . .	861,000	.7
Added to Atlantic Coast refinery storage. . . . .	1,027,000	.9
Balance . . . . .	1,226,000*	1.1
Total distribution. . . . .	116,520,000	100.0

\* The balance 1,226,000 includes losses in handling and such increases as were made to quantities held in storage at places other than refineries.



Of the 111,530,000 barrels marketed in the Atlantic Coast area, 104,617,000 barrels were delivered directly to consumers by refiners marketing in Atlantic Coast states and 6,913,000 barrels were delivered by the refiners to jobbers and marketers who, in turn, delivered to the consumer. Of the 6,913,000 barrels handled by jobbers and marketers, it was possible to obtain information as to final distribution on 3,583,000 barrels, leaving a quantity of 3,330,000 barrels distributed by marketers on which information as to final delivery is lacking.

In preparing the first study of Atlantic Coast gas and fuel oil distribution, that covering 1925, no attempt was made to obtain information as to distribution by jobbers and marketers. In making the 1926 study, however, the Bureau of Mines was able to obtain from some of the larger jobbers and marketers information covering distribution in 1925 and 1926, with the result that the 1925 figures have been changed to include the distribution by such marketers. Marketing companies which were not included in the 1925 study reported a 1926 distribution of 932,872 barrels which is included in the following statement covering 1926 distribution. Deducting this quantity from the 1926 total, the 1926 distribution of all companies included in the 1925 total would be 109,142,900 barrels as compared with a 1925 distribution of 109,564,043 barrels. This would indicate that there was little change during the year in the total demand for fuel oil in the Atlantic Coast area.

#### GAS AND FUEL OIL DISTRIBUTION BY USES

Atlantic Coast States, 1925-1926

(In barrels of 42 gallons)

Uses	1925	1926
Railroads . . . . .	4,165,693	4,327,478
Bunker Oil, including company tankers . . . . .	32,479,711	31,358,716
Gas and electric power plants . . . . .	15,015,420	16,041,485
Smelters and mines. . . . .	1,593,938	2,187,058
Shipbuilding, steel mills and foundries . . . . .	9,026,220	8,878,016
Automotive industries . . . . .	239,590	441,926
Sugar refineries. . . . .	1,111,283	895,784
Logging and lumbering . . . . .	51,417	42,830
Cement and lime plants. . . . .	440,575	488,933
Brick and clay plants . . . . .	623,918	933,426
Food industries . . . . .	1,021,896	1,066,616
Other manufacturing . . . . .	18,004,232	15,800,777
Heating of buildings. . . . .	6,113,875	7,744,267
U. S. Navy, Coast Guard, army transports. . . . .	1,732,802	1,034,654
Used as fuel by oil companies . . . . .	14,534,346	15,090,275
Non-segregated uses . . . . .	718,682	1,867,219
Exports . . . . .	2,690,445	1,876,312
Total distribution accounted for. . . . .	109,564,043	110,075,772
Non-segregated distribution by marketers. . . . .	-----	3,330,000
Total distribution. . . . .	(Not available	113,406,000



GAS AND FUEL OIL MARKETING ON ATLANTIC COAST, 1926

Distribution by Uses	Barrels	Per Cent
Bunker Oil, including company tankers . . . . .	31,358,716	27.7
Manufacturing . . . . .	19,670,292	17.4
Gas and electric power plants . . . . .	16,041,485	14.1
Used as fuel by oil companies . . . . .	15,800,777	13.3
Smelters, foundries, steel mills and shipbuilding plants . . . . .	11,065,074	9.7
Heating of buildings. . . . .	7,744,267	6.8
Railroads . . . . .	4,327,478	3.8
Non-segregated distribution by jobbers, etc. . . . .	3,330,621	2.9
U. S. Navy, Coast Guard, Army transports, etc. . . . .	1,034,654	.9
Miscellaneous uses. . . . .	1,867,219	1.7
Marketed in Atlantic Coast states . . . . .	111,530,081	98.3
Exported from Atlantic Coast districts. . . . .	1,876,312	1.7
Total Distribution, Atlantic Coast, 1926. . . . .	113,406,393	100.0

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The following table shows the total quantity of gas and fuel oil marketed in each of the states during 1926. Deliveries of bunker oil are credited to the state in which delivery was made and exports to the district from which shipment departed.

State	Barrels Marketed
Maine	1,643,572
New Hampshire	179,615
Vermont	108,816
Massachusetts	12,330,119
Rhode Island	4,633,549
Connecticut	2,427,964
New York	35,872,875
New Jersey	17,136,766
Pennsylvania	17,672,589
Delaware	884,014
Maryland	5,415,639
District of Columbia	758,570
Virginia	1,558,646
North Carolina	360,127
South Carolina	1,485,982
Georgia	1,604,517
Florida	9,305,602
Total Atlantic Coast	113,406,393

The lowered price of fuel oil in California during 1926 affected the Atlantic Coast situation in two ways. First, the quantity received by Atlantic Coast distributors, including gas oil, increased from 1,298,000 barrels in 1925 to 12,266,000 barrels in 1926. The second influence would seem to be in the decreased amount delivered as bunker oil and to naval vessels. Deliveries of bunker oil at California points showed a considerable increase in 1926 over 1925, which would indicate that some vessels which had received bunker oil at Atlantic Coast ports during 1925 were bunkered at California ports during 1926. Such a change applied to oil tankers alone undoubtedly would be of sufficient magnitude to result in the decrease shown.

The increase shown in the consumption of gas and fuel oil by gas and electric power plants is accounted for almost entirely by increases shown in the five South Atlantic states. The distribution in these states increased from 1,616,997 barrels in 1925 to 2,647,957 barrels in 1926, while, of the five states, Florida alone showed an increase from 1,106,653 barrels in 1925 to 1,830,543 barrels in 1926. The United States Geological Survey reports an increase in the consumption of oil as fuel in power plants in the South Atlantic states from 1,724,000 barrels in 1925 to 2,299,000 barrels in 1926, while reports received from some of the larger manufacturers of artificial gas in the same region indicate a similar increase in the consumption of oil for the enrichment of water gas.

The decrease shown under the heading of "Other manufacturing" occurred largely in the New England states and probably indicates a smaller consumption by the textile and shoe industries in that region, which are the largest consumers. The distribution under this heading for the six New England states decreased from 10,534,084 barrels in 1925 to 8,813,121 barrels in 1926.

Information pertaining to the distribution of gas and fuel oil, divided by states and industries, was made available through the courtesy and cooperation of all of the major refining and marketing companies operating in the Atlantic Coast area. The companies cooperating in this survey and whose deliveries are included in the total tabulation are: Asiatic Petroleum Company, Ltd., Atlantic Refining Company, Barber Asphalt Company, Beacon Oil Company, Cities Service Refining Company, Crew Levick Company, Galena Signal Oil Company of Texas, Gulf Refining Company, Humble Oil and Refining Company, New England Oil Refining Company, Pan American Petroleum and Transport Company, Paragon Refining Company, Petroleum Heat and Power Company, Prudential Oil Corporation, Pure Oil Company, Roxana Petroleum Corporation, Sinclair Refining Company, Standard Oil Company of Kentucky, Standard Oil Company of New Jersey, Standard Oil Company of New York, Sun Oil Company, The Texas Company, Tide Water Oil Company, Vacuum Oil Company and the Warner-Quinlan Company, in addition to which there were a large number of smaller marketers who courteously offered information relative to their distribution. The cooperation of these companies is gratefully acknowledged.

On the following three pages will be found tables showing the distribution of gas and fuel oil in the Atlantic Coast area, divided by states and industries.



# DISTRIBUTION OF GAS OIL AND FUEL OIL - MIDDLE ATLANTIC STATES - 1926

	Maine	N. H.	Vermont	Mass.	R. I.	Conn.
Railroads . . . . .	3,738	-	2,195	247,553	15,818	57,331
Steamships (Inc. tankers) . .	16,321	-	-	1,221,531	28,374	19,108
Gas and electric power plants	134,871	37,289	24,772	1,637,904	324,836	472,675
Smelters and mines . . . . .	-	299	-	3,944	235	1,526
Shipbuilding, steel mills and foundries . . . . .	25,193	-	5,447	396,937	282,362	391,745
Automotive industries . . . .	-	-	-	12,985	-	28,851
Sugar refineries . . . . .	-	-	-	20,000	-	-
Logging and lumbering . . . .	-	14,981	-	-	-	410
Cement and lime plants . . . .	-	-	12,706	116,461	-	3,163
Ceramic industries . . . . .	-	3,323	3,198	49,243	-	90,455
Food industries . . . . .	9,705	472	2,341	112,356	10,509	13,178
Other manufacturing . . . . .	1,365,092	78,415	10,425	4,040,821	2,416,161	902,207
Commercial heating . . . . .	38,929	31,807	4,901	1,932,934	642,810	187,006
Domestic heating . . . . .	6,953	6,920	6,164	237,436	18,116	36,549
U. S. Navy, Army transports and coast Guard . . . . .	-	-	-	207,570	58,378	65,821
Used in company operations . .	9,412	714	719	1,328,658	490,368	2,414
Miscellaneous uses . . . . .	3,651	1,005	344	303,235	278,243	8,751
Exports . . . . .	522	-	26,228	194,421	-	-
Non-segregated distribution by jobbers, etc. . . . .	26,185	4,385	9,376	216,130	67,319	146,774
Totals . . . . .	1,643,572	179,615	108,816	12,330,119	4,633,549	2,427,964

Note: Major items under "Other manufacturing" include deliveries to the following industries: textiles, paper, shoe and leather, bleacheries, explosives, asphalt and building materials, rubber and chemical.



# DISTRIBUTION OF GAS OIL AND FUEL OIL - MIDDLE ATLANTIC STATES - 1926

	New York	New Jersey	Penna.	Del.	Md.	D. C.
Railroads . . . . .	1,079,436	37,067	304,863	5,386	55,746	815
Steamships (Inc. tankers) . .	20,362,273	465,851	5,083,034	9,136	1,176,562	-
Gas and electric power plants	6,264,752	1,103,676	2,201,434	78,011	513,690	549,618
Smelters and mines. . . . .	346,198	460,715	13,129	-	356,000	-
Shipbuilding, steel mills, and foundries. . . . .	555,562	1,810,574	3,701,388	193,160	1,450,183	-
Automotive industries . . . .	175,579	119,099	18,674	-	-	-
Sugar refineries. . . . .	9,755	552,772	97	-	62,450	-
Logging and lumbering . . . .	923	1,581	-	-	-	-
Cement and lime plants. . . .	184,368	-	172,117	-	-	-
Ceramic industries. . . . .	261,366	253,898	102,194	27	13,200	-
Food industries . . . . .	139,968	152,286	57,971	7,148	18,789	-
Other manufacturing . . . . .	1,079,163	2,344,664	1,030,290	495,596	313,140	-
Commercial heating. . . . .	1,810,772	217,850	1,290,929	59,125	35,147	187,166
Domestic heating. . . . .	564,654	122,634	225,431	475	-	9,709
U.S.Navy, Army transports and Coast Guard. . . . .	338,760	343	199,919	2,058	53,285	10,109
Used in Company operations. .	1,754,760	7,034,682	2,316,224	-	1,230,403	-
Miscellaneous uses. . . . .	260,620	154,064	68,101	33,892	2,912	1,153
Exports . . . . .	675,443	-	708,394	-	-	-
Non-segregated distribution by jobbers, etc. . . . .	8,523	2,332,441	178,400	-	134,132	-
Totals. . . . .	35,872,875	17,136,766	17,672,589	884,014	5,415,639	758,570

Note: Major items under "other manufacturing" include deliveries to the following industries: textiles, paper, shoe and leather, bleacheries, explosives, asphalt and building materials, rubber and chemical.

DISTRIBUTION OF GAS OIL AND FUEL OIL - MIDDLE ATLANTIC STATES - 1925  
(Barrels of 42 Gallons each)

Distribution by Uses:	Virginia	No. Car.	S. C.	Ga.	Fla.	Totals for Atlantic Coast
Railroads . . . . .	59,686	17,075	4,591	42,746	2,393,432	4,327,478
Steamships (Inc. tankers) . . . .	1,079,777	13,297	500,931	211,446	1,171,075	31,358,716
Gas and electric power plants . .	1,117,754	86,230	62,004	537,426	1,830,543	16,041,485
Smelters and mines . . . . .	7,904	153	-	-	996,955	2,187,058
Shipbuilding, steel mills and foundries . . . . .	61,386	-	-	1,059	-	8,878,016
Automotive industries . . . . .	23,384	52,626	-	533	10,195	441,926
Sugar refineries . . . . .	-	-	-	250,710	-	895,784
Logging and lumbering . . . . .	5,344	451	600	344	18,196	42,830
Cement and lime plants . . . . .	-	-	-	-	118	488,933
Ceramic industries . . . . .	10,788	1,375	21,234	36,501	86,619	933,426
Food industries (canning, baking refrigerating, etc.) . . . . .	42,477	9,786	4,883	98,911	385,836	1,066,616
Other manufacturing . . . . .	32,628	20,535	18,637	11,155	1,641,848	15,800,777
Commercial heating . . . . .	3,700	20,607	155	14,015	28,277	6,506,130
Domestic heating . . . . .	-	1,425	-	1,571	100	1,238,137
U. S. Navy, Army Transports and Coast Guard . . . . .	8,812	14,699	45,477	-	29,398	1,034,654
Used as fuel by oil companies . .	39,257	-	608,796	262,842	11,026	15,090,275
Miscellaneous uses . . . . .	9,278	83,482	16,887	34,922	606,679	1,867,219
Exports . . . . .	58	-	177,072	87,684	6,490	11,876,312
Non-segregated Distribution by jobbers, etc. . . . .	42,413	38,386	24,715	12,627	88,815	3,330,621
Totals . . . . .	1,558,646	360,127	1,485,982	1,604,517	9,305,602	113,406,393

Note: Major items under "Other manufacturing" include deliveries to the following industries:  
textiles, paper, shoe and leather, bleacheries, explosives, asphalt and building materials,  
rubber and chemical.

Information Circular, Bureau of Mines, Department of Commerce.



November, 1927.

STATE GEOLOGICAL SURVEY

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

PERMISSIBLE EXPLOSIVES DEFINED

By Charles E. Munroe <sup>1</sup>

The first list of Permissible Explosives was approved May 15, 1909 and the 17 compositions announced on that list were the first permissible explosives to exist. In announcing that these explosives had passed all the test requirements there were added provisions governing conditions of use and of constancy in the explosive, all of which must be conformed to in order that each of these explosives could be and continue to be a "permissible explosive." Some 14 other general lists, with several supplementary lists, of permissible explosives tested in the intervening period, together with several schedules dealing with the making of the tests by the United States Bureau of Mines and the fees to cover the tests, have been published by the bureau. In most of these publications, though unfortunately not in every one of them, it is announced that, in addition to passing the prescribed tests, to be permissible the explosive must always be used in the prescribed manner.

It is, therefore, to be borne distinctly in mind that a permissible explosive is a carefully specified system in which the designated explosive is but one of the factors (though it includes several other of the factors in its chemical and physical requirements), for the weight of the charge, the kind of electric detonator and the kind of stemming used must each conform with the specifications, while, further, the shot must not be a depending one, or bored into the solid, or have a burden so heavy that the shot is obviously liable to blow-out and the shot must not be fired in the presence of a dangerous percentage of fire-damp.

In mining coal conformity with and observance of each item of the above specification is absolutely essential to maintain the permissibility of the explosive used. With the failure to observe any one of the items in this specification, the explosive ceases to be permissible. Hence, if an accidental explosion occurs in which a "permissible explosive" is involved, such accident cannot properly be charged against the "permissible explosive" if there was a failure to conform with any item of the specifications, for, with that omission, the explosive had ceased to be a "permissible explosive."

Permissible explosives are selected by means of carefully prescribed tests, applied to each of them in a definitely prescribed manner, from among explosives developed in manufacture. Permissible explosives are high explosives as they detonate and their explosions, in use, are initiated by detonators.

1 - Chief Explosives Chemist, Bureau of Mines, Department of Commerce.



Among permissible explosives we find explosives of the dynamite, ammonia dynamite and the gelatin dynamite classes. They are selected because they will detonate and throw down the coal. The fact that any one of these explosives is selected for use as a permissible explosive does not change its nature. It still in manufacture, transportation, storage and use must be treated as a high explosive; as a member of one of the classes of dynamite or their congeners.

If, in the course of manufacture of such an explosive, through carelessness or other cause, the explosive exploded, this can have nothing whatever to do with the fact that this explosive had been designated as a permissible explosive when used under definitely prescribed conditions in mining coal.

In transportation if an explosion occurs because the explosive is stored in a car with loose machinery, or it is involved in a wreck or fire, or when taking it into a mine it encounters a stray current or coronal discharge, this can have nothing to do with the "permissibility" of the explosive.

In storage, if an explosion occurs because of lightning, or from detonators or other explosives stored with it, none of the causes has the least connection with "permissibility" and such accidents cannot properly be charged to permissible explosives.

Many other examples under other circumstances might be cited, all showing that permissible explosives by passing the tests for permissibility and being placed on the "permissible list," have not been in any manner changed. They each retain the explosive characteristics they possessed at the time they were tested for permissibility and may be accidentally exploded by any of the causes to which such explosives respond. The term "permissible explosive" assigned to them simply indicates that they have been found safer than other explosives for use in mining coal provided they are used in precise accordance with the specifications made and provided for them.

Hence, in any instance, when it is alleged that a permissible explosive had undergone accidental explosion or failed in use, it must be proved that the explosive at the time was being used in the mining of coal and that it was being used in absolute accordance with the specifications, for, if they were deviated from in any particular, the explosive automatically ceased to be a permissible explosive.

A review of this topic suggests that there, perhaps, should be another item added to the specifications of a permissible explosive and that is an age limit. All know that time effects changes in everything, the rate varying with each substance and the conditions of exposure. Realizing this, the U. S. Bureau of Mines has from the outset urged operators to use fresh explosives. With the introduction of gelatin dynamites, it is noted that these age changes which affect the action of the explosive occur sooner with the gelatin dynamites than with other explosives, and yet the former possess properties which make them most desirable for use. It is unfortunate when the properties or behaviors of a few explosives necessitate drafting additional specifications for all. But circumstances sometimes arise to require it.- Information Circular, Bureau of Mines, Department of Commerce.

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

### MINE SAFETY AS AFFECTED BY ELECTRIFICATION

By K. L. Marshall<sup>1</sup>

This paper is designed to supplement Report of Investigations No. 2541 entitled "Electrical Safety Inspection: Suggestions for Mine Safety Engineers," by L. C. Ilsley<sup>2</sup>. Serial 2541 deals chiefly with the conditions leading to the safety of the electrical equipment used in coal mines, whereas this paper points out the features leading to safety in the use of electricity in mine operation, more especially as related to mining methods and ventilation.

Other things being equal, the hazard to life through electric shock decreases as the operating voltage is decreased. There are on record a number of fatalities from electric shock due to contact with circuits of 440-volt alternating current and 500- and 600-volt direct current, but the writer knows of very few fatalities from electric shock in underground mines where voltages of 220-volt a.c., current and 250-volt d.c. were in use. Although 220 a.c. and 250 d.c. are the lowest voltages in common use for motors of the size employed in mines, the use of electricity underground at higher voltages than these should in general be discouraged in mines, particularly for circuits as installed in mines in the United States without earthing or grounding.

A number of companies have changed over to these lower voltages and it is reported that the cost of rewinding motors for lower voltage duty is not excessive.

Electricity used at the mines is either purchased from a power company or generated in the mining company's own power plant; the former is always and the latter is nearly always delivered or generated at a voltage higher than that used to operate the underground electrical equipment. Hence the place at which the higher voltage used in surface transmission is transformed or converted to lower voltage for mine use is important. Maximum safety is afforded when this is done at transformer banks or substations on the surface, and the operating current circuits of low voltage are carried through drill holes to load centers in the mine. Hence this practice is to be preferred.

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On the other hand, excessive cover sometimes makes the cost of drilling prohibitive and the extent of mine development makes the cost of copper and line losses excessive at low voltage. In such cases, underground transformers and substations are used. However, before deciding upon such a course, the high installation cost and maintenance cost of underground high-tension lines and cables should be considered, together with ease of inspection and repair to surface equipment as compared with underground equipment.

Underground transformers and substations should be placed on separate splits of air, be of fire-proof construction and be fenced to prevent unauthorized persons from entering. Some companies equip their transformer rooms with fire doors which close when a light cord or canvas strip burns through and releases the catches holding such doors open. Floors of transformer rooms should be walled so that burning oil can not flow out upon an entry. This is of especial importance on pitching seams.

Large pumps, underground hoists, etc., are at times driven with high-voltage motors, generally 2300 volts. All such installations should be treated as described above for substations and wiring should be in conduit and otherwise arranged to conform to underwriters' requirements for surface equipment of similar size.

Metallic-armor-covered cables, with metal covers continuous throughout and properly grounded, as discussed in Serial No. 2541, are considered the safest means of conducting high-voltage circuits underground. Where such cables shall be carried is largely a problem of mine conditions. If the roof is good and the entry is not a haulageway, the cable may be supported from the roof on a messenger wire. If the entry is used as a travel way for men, guards should be used to prevent contact and especial care should be taken to see that ground connections are kept in place and effective. In any event the entry used should be an intake airway. If the roof is bad and the floor does not heave, cables may be buried in the floor to advantage. Where cables must be carried in haulageways, they should be buried in floor or carried in channels cut in roof or possibly recessed in rib so that they cannot be damaged by trip wrecks.

All underground circuits should have all the protective devices, oil switches, circuit breakers, section switches, fuses, etc., that would be required on good surface installations. This is fully covered in Serial No. 2541.

Protection against lightning on circuits entering the mine is a feature that is sometimes overlooked. Lightning can and has gone underground on power wires. The writer knows of one instance where lightning traveled at least 3,000 feet underground. In this case it was stopped by a well grounded switchboard and oil switch-cases and did not damage the motor-generator sets. The possibility of such damage is another reason for using good ground connections wherever possible.



In mines which give off explosive gas, provision should be made for opening all electrical circuits entering the mine in case the fan is stopped, unless the discontinuance of the electric current would entail other and more serious hazards. Arrangements of this kind may be made through use of vanes or water gages wired to circuit breakers. In very gassy mines the cutting off of the power should take place when the fan slows down to half speed.

All wiring in gassy mines should be installed only in intake air carried on main intake entries or the intake entries of splits made permanent by the use of overcasts, stoppings and regulators. Intake air controlled by doors, curtains or temporary stoppings, any of which may be easily or accidentally disarranged, should not be considered a safe medium in which to install electric circuits.

Electrical equipment such as pumps, air compressors, etc., unless of permissible types, should not be installed ahead of the last permanent stopping in crosscuts between intake and return entries and never past the last crosscut left open, even if a second open crosscut has been completed. The same rule should apply to the end of power wires for portable (cable reel) equipment, and to the trolley wire for motor haulage. These rules are necessary because such places, whether dead ends or on temporary canvas, often become gas filled even with fan operating normally.

Portable equipment, such as electric mining machines, electric drills, electric loading devices, electrically driven conveyors, and electric fans or blowers, when equipped with open motors, should not be used in a gassy mine. If they are used in a gassy mine, they must receive careful consideration if the mine or the miners are to be even fairly adequately safe-guarded. Its portability makes the use of such equipment difficult of safe supervision, and the foreman or other responsible official may not always know just how or where it is being used. All such equipment should have the protection of frequent examination for gas in the places in which it is used and preferably this examination should be made by a competent certified official. Where gas is found frequently, only properly maintained and inspected "permissible" equipment should be used, and then only with the same gas examination as for open type equipment. The permissible motors and accessories should be expected only to protect against an unexpected or undetected occurrence of gas.

All electrically equipped gassy mines should have outlets of all abandoned or sealed workings connected only to return airways, and electric circuits or equipment should never be installed or used where they may be in the path of air and explosive gases leaking or released from such areas. Any unworking part of a mine not subject to the full inspection and supervision that the active workings receive should have all electrical power cut off and such power should not be again turned on until a complete examination of the section has been made, such examination to include the inspection of power wires and equipment.

Although the foregoing practices leading to safety in the use of electricity are the maximum that may reasonably be expected in mines that are classed as non-gassy or slightly gassy, the writer believes such practices to be the minimum that may be used in gassy mines without introducing a distinct and ever present hazard. - Information Circular, Bureau of Mines, Department of Commerce.



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Circular No. 6056  
January, 1928.

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

PREVENTION OF ACCIDENTS WITH EXPLOSIVES IN THE TRI-STATE ZINC  
AND LEAD ORE PRODUCING DISTRICT

By S. P. Howell\*

Introduction

Premature explosions and misfires are responsible for a large majority of the accidents resulting from the use of explosives in the Tri-State zinc and lead ore producing district. Accident Prevention Bulletin No. 56, issued by the Tri-State Zinc and Lead Ore Producers Association, shows that 6 fatal accidents in 1925 and 7 in 1926 were caused by handling high explosives and detonators. Analytical study of these accidents shows that 6 of the fatalities were due to premature explosions, 3 occurred while holes were being loaded, 2 were caused by picking into failed shots, and 1 was the result of a dormant shot. However, accidents that occur while a hole is being loaded are premature-explosion accidents in the broader sense, while those classed as "picked into failed shots" and "explosion of dormant shot" are really due to misfires; hence 12 of the 13 fatalities may be ascribed to one or the other of these two general types of accident. In view of this preponderance, the following discussion of means of preventing explosives accidents will be confined chiefly to those caused by premature explosions and misfires.

The observations concerning blasting practice upon which this paper is based were made in March, 1927, during a visit to the Tri-State district while the author was assisting in an accident-prevention campaign. Arrangements made by R. V. Ageton, accident-prevention engineer and the courtesy of mine officials enabled him to inspect 10 mines in the district with F. H. Nesbit, assistant accident-prevention engineer, and to confer with other accident-prevention engineers, superintendents, ground bosses, powder men and machine men, individually and in groups. The full cooperation accorded by each of these individuals and groups is gratefully acknowledged.

CONDITIONS SURROUNDING THE USE OF EXPLOSIVES IN THE TRI-STATE DISTRICT

General Practice

The shafts of the mines visited are 220 to 343 feet deep. The principal ores mined contain galena and sphalerite in a flint gangue. The minerals are either disseminated or occur in veins, veinlets, or vugs.

\* Explosives Engineer, U. S. Bureau of Mines.



Ore is mined by the underhand-stoping method and the different types of blasting may be classed as "drift," "pull drift," "slabbing," stope and "split," loading in chambers or loading "slick," "squibbing" (chambering), and block holing.

The so-called "drifts" are driven at or near the top of the ore body and are the pioneering cuts above the stopes. The "drifts" are not as accessible as the "pull drifts," but holes can often be placed to greater advantage because of the width of the free face.

The "pull drifts" correspond to the main drifts in other metal-mining districts. One such "pull drift," 6 feet by 6 feet was blasted with fourteen 6-1/2-foot holes using the 4-hole pyramid cut. The 3 lifters each contained two "shots" (primers). One 50-pound case of 60 per cent gelatin dynamite was used in the 4 cut and 4 reliever holes, and one 50-pound case of 40 per cent gelatin in the 3 back holes and 3 lifters. The holes were wet.

The usual depth of "drift" holes and "pull drift" holes is 9 feet.

Stope rounds are used on or near the bottom of the stope and normally vary from 1 to 5 holes per round, are up to 16 feet deep, and their placement depends largely on the height and shape of the unbroken rock. The lower holes point slightly downward. Stope holes are "squibbed" or enlarged by preliminary smaller dynamite charges if the burden requires it or if the rock can not be otherwise broken without forming boulders. Otherwise, holes are loaded "slick," that is, without being squibbed.

A very high stope may require holes called "splitters" between the drift and stope holes. These splitters are drilled, squibbed, and blasted similar to stope holes. Many stope and splitter holes are wet, although certain mines have few wet holes. Splitter holes are squibbed if the burden is great or the rock difficult to blast.

The time between the preliminary squibbing shots and between the final squibbing shot and the primary blast was standardized at 24 hours in one mine visited.

The larger boulders are broken by blasts in short block holes.

Because of crevices and cavities in the rock the drift holes, splitter holes, and stope holes are frequently ragged, and unless care is taken in charging, the cartridges may fall into these openings. In drilling, the rock often crumbles easily, especially at and near the collar of the holes, so that the collars are much enlarged. For example, the collar of one hole was oval in section, 5 inches wide, and 12 inches long; other holes were smooth throughout and could be easily charged by simply pushing the cartridge "home." In most mines the large percentage of ragged holes necessitates the "leading in" of single cartridges and of the "shot" by placing them on the copper spike of a copper-ferruled pine tamping bar. When thus placed in position the cartridges are tamped firmly with the wooden end of the tamping bar.

At the mines visited powder men or machine men charge the holes and spit the fuse. Cartridges are usually slit once in order that a high density of loading can be procured.

The mines of this district generally use 1-1/4-inch hollow drill steel, though one mine uses 1-1/8-inch, and some mines use some 1-inch as well as other sizes. In one mine the steel used for drilling stope and "splitter" holes is 2 to 20 feet long, by 2-foot increments, while the gage diameter of the drill bit varies from 2-3/4-inches for the starter to 1-5/8 inches for the finisher by 1/8-inch increments. For shorter holes the finisher has a gage of 2-1/2 inches. Water drills are used, and wet drilling prevails.

Screen goggles are used by some machine men and their helpers while starting and blowing out holes.

### The Explosives

Gelatin, extra gelatin, and ammonia dynamites of 33 and 35 per cent grades, and gelatin dynamites of 25, 30, and 40 per cent grades in 1-1/4-inch diameter are commonly used. However, some 20-60 per cent gelatin dynamite is used, the latter in cut holes and relievers in "pull drifts," and a very small proportion of the explosive is in 1-1/8-inch diameter cartridges. Explosives are used fresh, deliveries being made at not more than one-month intervals. The district is particularly fortunate in this respect, and the practice is a direct result of three of the four manufacturers who supply explosives to the district having plants nearby. The explosive is delivered 1, 2, 3, or even 6 times a week from manufacturers' or jobbers' distributing magazines to some individual mines. The largest delivery to one mine that was noted was sixty 50-pound cases. Gelatin dynamite is commonly used in wet holes, in places where there was inadequate ventilation, for squibbing, and at some mines for "shots" or primers when the main charge is ammonia dynamite. If deliveries are frequent the explosives are commonly brought by the manufacturer or jobber to the collar of shaft, where they are promptly taken underground in the ore "cans," each accommodating about ten 50-pound cases. They are stored in a dry place as far from the shaft and working place as is feasible. Larger deliveries are made to outside magazines from which daily deliveries are made underground. The district uses approximately 8,000,000 pounds of high explosives annually.

### The Detonators

No. 6 detonators are used in "shots" or primers of ammonia dynamite and at some places in "shots" of gelatin dynamite. Some mines use No. 8 detonators exclusively in gelatin dynamite "shots".

### The Fuse

Fuse with a rated burning speed of 40 seconds per foot is extensively used, but in some mines the fuse used has a rated burning speed of 30 seconds. Both brands employed are designed for use in very wet work. Fuse was received



in coils, each containing two 50-foot lengths. It was commonly measured by a standard length of fuse, although a scale cut on a bench was sometimes used. Fuse used in dependent shots was trimmed about 5 inches. Fuse was spit with a carbide lamp. Blasting during the shift is infrequent and is discouraged.

Capped fuse is commonly made up at primer stations either above ground or underground by crimping the detonator on the 6-foot to 10-foot measured fuse with hand crimpers. One bench crimper was observed in use underground.

### Primers ("Shots")

"Shots" are made in a variety of ways. Usually the detonator is placed in one end of the cartridge so as to be isolated from the copper spike of the tamping bar, which is inserted in the opposite end of the "shot". Where no "shot tube" is used, the fuse is secured in place by tying the loosened paper of one end of the cartridge around it with cord (see fig. 1) or by lacing the fuse through the cartridge. Where the McLaughlin & Anderson "shot tube" (see fig. 1) is used the detonator is commonly placed in the end of the cartridge near the wooden plug. The hole in the center of the plug does not go through the plug by 1/4 inch, thus isolating the detonator from the copper spike of the tamping bar. When the Chicago type of "shot tube" (see fig. 1) is used the detonator is commonly placed in the far end of the cartridge so that the detonator is at least 4 inches from the copper spike of the tamping bar. The writer's observation was that the fuse was laced through less than half of the "shots" used in the mines visited. In all instances noted save one the fuse emerged from the side of the end of the "shot", permitting the spike to be placed in the opposite side of the end of the "shot" protecting the fuse from the tamping bar. In all holes of primary blasts the detonator was pointed toward the bottom of the holes. In all blasts noted in which there were dependent shots the primer was placed near the bottom of the hole, thus preventing the fuse from being cut by an overbreak. In squibbing and in single stoep holes the primer was at or near the top of the charge.

Many powder men prefer to use gelatin dynamite in "shots" because these are easily made with plastic explosive.

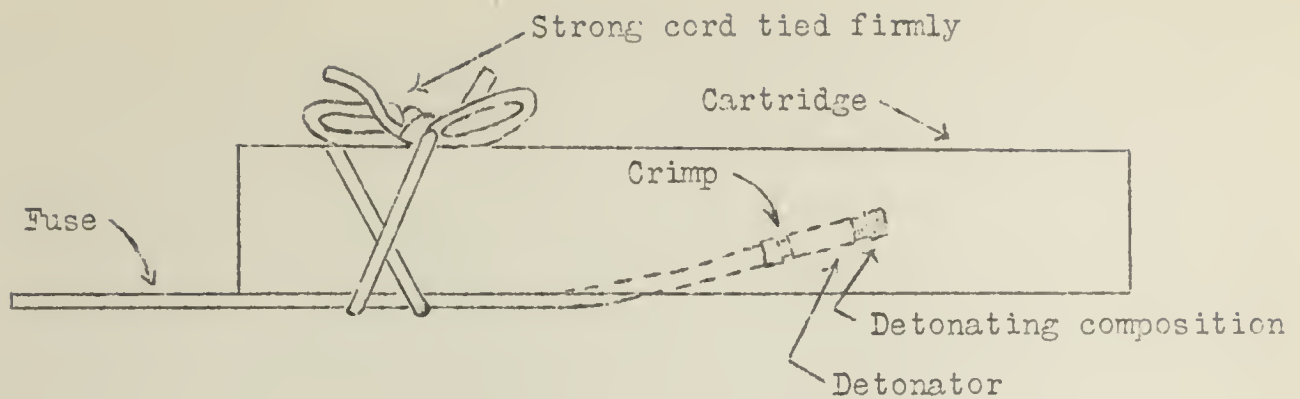
### Stemming

Stemming was not used in any holes. One mine reported unfavorably on the use of stemming after a trial. It is noted, however, that two of the larger mining companies plan to use stemming in all of their mines. This is, of course, the best practice.

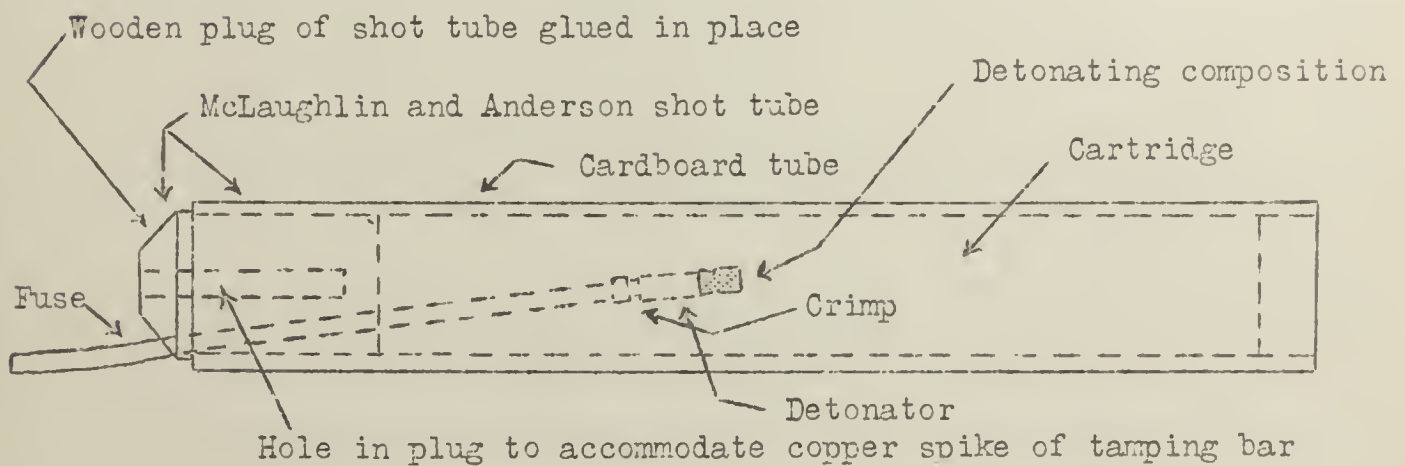
### PREVENTING MISFIRES

As previously noted, 3 fatal accidents in two years were caused by misfires. These can not be attributed to aged and therefore insensitive explosives because explosives in this district are very generally used in a fresh condition. The fuse is likewise of high quality. The writer believes that when fuse is used misfires can be largely, if not wholly, prevented in any metal mine using high-grade explosives and blasting supplies (a) if proper standard primers (shots) are adopted; (b) if care is used in preparing the charge and preparing and charging

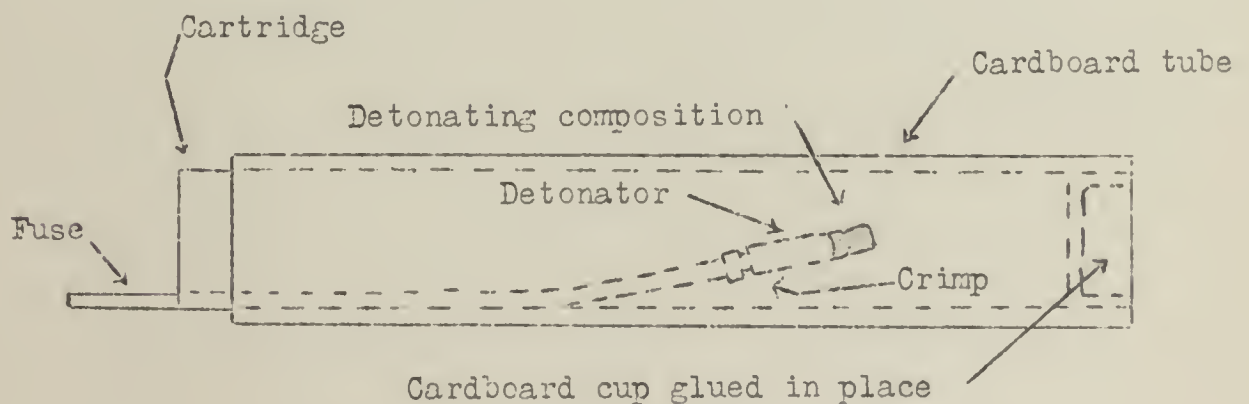




Primer (Shot) without shot tube



Primer (Shot) made with McLaughlin and Anderson shot tube



Primer (Shot) made with Chicago shot tube



the holes; (c) if stemming is used; (d) if No. 8 detonators or electric detonators are used in primers made with gelatin dynamite which is not fresh; and (e) if "shots" in dependent holes are placed near the bottom of the charge.

In this district, where a substantial proportion of the holes are ragged or intercept crevices or pockets, the use of "shot tubes" (see fig. 1) seems desirable as a precaution against misfires. Several hundred thousand "shot tubes" have been successfully used. At a given mine the "shot" should be standardized so that these conditions prevail: A single type of tube; fuse not laced through cartridges; fuse emerging from side of end of cartridge; "business" end of detonator in center line of cartridge; detonator points toward bottom of hole; at least 4 inches between detonator and copper spike of tamping bar; and the inside diameter of tube to fit primed cartridge firmly but not loosely or tightly. These conditions are fulfilled if "shots" are made as shown in Figure 1.

The end of the fuse to be inserted in the detonator should be cut off squarely with a sharp knife and the freshly cut end inserted in the detonator so as to touch the detonating composition gently.

Detonators may be crimped on the fuse with hand crimpers which are in good condition. The greatest uniformity in crimping obtains, however, if bench crimpers are used and operated by a trained man especially assigned to the job.

For use in wet work, the fuse at, and for a few inches above, the detonator should be covered with a waterproofing compound, such as P. and B. paint, Kapseal, and Celakap but not with oil or liquid grease.

In very wet work delay electric detonators with enameled copper legs should be used in dependent shots.

The greatest assurance against misfires obtains when electric detonators or delay electric detonators are used.

Before being charged the holes should be cleaned of loose material. This may be done by blowing out the residual cuttings or by scraping out smooth holes. Loose material in a borehole may promote misfires by so separating cartridges that the whole charge is not detonated. A high charging density can be attained by firmly tamping the charge with short firm taps with a wooden tamping bar. Several cartridges of moist, fine stemming, such as moist plastic clay, should be used in each hole of primary blasts. This prevents misfires by securing the explosive in place. In another mining district the writer has observed cartridges on the muck pile which had been pulled out of a hole by the blast from a previously fired hole of a round, even though two cartridges of poorly tamped stemming were in the hole. In this case the fuse of the dependent hole had not been spit. Had it been spit the ejected cartridges would have been buried in the muck pile. Such blasts would, on occasion, with unstemmed holes, displace or eject the "shot" or primer and cause a misfire. Among its other advantages stemming should be used to reduce misfires.



In general, No. 8 detonators are recommended for use with "shots" or primers that are made with gelatin dynamite, but under the specially favorable conditions obtaining in many of the mines of the Tri-State district, No. 6 detonators appear to be wholly satisfactory for use with gelatin "shots". These special conditions are: The use of fresh gelatin dynamites; the storage of the detonators above ground in cool, dry places; and the use of "shot tubes" in holes that are difficult to charge.

"Shots" should be placed far enough into the charge of a dependent hole so that, should the hole be cut off, the powder core of the fuse will be burning beyond the point of cut off.

#### PREVENTING ACCIDENTS WHILE CHARGING AND FROM PREMATURE EXPLOSION

Premature explosions may result from improper methods of opening boxes of explosives. They should be opened with wooden tools, such as wooden wedges and wooden mallets.

Assuming that fresh explosives and high-grade blasting supplies such as are used in this district are employed, accidents during charging and from premature explosion can be prevented by care in charging by a standard method. The use of "shot" tubes makes it possible to place the "shot" in safety, for they not only prevent the "shot" from falling into crevices and chambers or getting crosswise of the hole but hold the detonators in place in the cartridge. At a given mine a standard "shot" should be adopted and used in all "drift," stope, and "splitter" holes. In mines free from ragged holes "shot tubes" need not be used. In any event, the fuse should be so secured that the detonator is anchored in place in the center line of the cartridge and at least 4 inches from the copper spike when placed in the cartridge. The "shot" and the cartridges immediately following it should be placed in the hole carefully. Other cartridges should be pressed home firmly but never forcibly. The spiked end of the tamping bar should be used only for leading in the cartridges and the "shot"; tamping should be done only with the wooden end of the tamping bar. Explosives should be protected from sparks and flames; thus, fires, open lights or smoking should not be permitted near explosives. The holes should be charged just before firing time. Stemming should be used. From the time the charging of holes is begun until they are fired all other work near the holes should cease. Only those required to charge and tamp the holes should be permitted near the holes, and they only while engaged in the work. No matter how remote the probability of a premature explosion, the minimum number of persons should be in the danger zone.--Information Circular, Bureau of Mines, Department of Commerce.

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STATE GEOLOGICAL SURVEY

INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

THE DETERMINATION OF CARBON MONOXIDE IN MINES  
WITH THE "IODINE PENTOXIDE" DETECTOR

By G. S. McCaa<sup>1</sup> and John A. Davis<sup>1</sup>

Introduction

Carbon monoxide is often found in mines, particularly during and after mine fires and after mine explosions. This gas has the property of combining with the haemoglobin or red coloring matter in the blood and thus preventing the normal delivery of necessary oxygen to the various tissues of the body. Because of this, headaches and discomfort frequently result after 2 or 3 hours of breathing an atmosphere containing as little as 0.04 per cent of carbon monoxide, while exposure to a concentration of 0.3 per cent usually produces unconsciousness in 20 or 30 minutes -- followed by death if the victim is not promptly removed to fresh air. The gas is all the more dangerous because it is colorless, odorless, and tasteless, thus affording no warning of its presence that can be perceived by the unaided human senses.

The various methods commonly used by the Bureau of Mines for determining the presence of carbon monoxide in mine air include: Observation of the effect on small animals, particularly canary birds and mice; the pyrotannic acid method of determining carbon monoxide in blood samples; volumetric gas analysis by absorption or combustion; and the iodine pentoxide method. That canary birds or mice are more susceptible than human beings to the effects of carbon monoxide has so long been recognized as a means of detecting this gas in mines that further comment is not needed. The underground use of the pyrotannic acid method is somewhat restricted by its limitation to air containing not over 0.2 per cent of carbon monoxide. Volumetric gas-analysis methods require technical skill and training on the part of the analyst, as well as apparatus that is either too delicate or too cumbersome to be carried about underground, hence these methods are employed almost exclusively in the laboratory. The iodine pentoxide hoolarite method, however, permits the use of a carbon monoxide detector which determines the amount of carbon monoxide in mine air quickly, simply, and with reasonable accuracy. As the method is of comparatively recent origin, it is not known as well as might be advantageous to men concerned with fighting mine fires or with rescue and recovery after mine explosions. The following description of the detector used by the Bureau of Mines and discussion of its operation should therefore be of interest.

1 - Mining Engineer, Bureau of Mines, Department of Commerce.



### Description of the Detector

The most essential feature of the detector is a small glass tube (Fig. 1, DN-4) containing granular pumice stone impregnated with a mixture of iodine pentoxide and fuming sulphuric acid. This mixture is called hoolamite after Hoover and Lamb, who patented the formula ( $I_2O_5 + H_2SO_4 + SO_3$ ) on November 4, 1919. When air containing carbon monoxide is forced through the tube by means of a rubber aspirator bulb and suitable valves (illustrated in Fig. 1) iodine is liberated and the original white of the granules is changed to various shades of bluish green or even violet-brown or black, depending upon the amount of carbon monoxide. The chemical reaction that liberates the iodine is indicated by the formula:  $I_2O_5 + 5CO + H_2SO_4 + SO_3 = 5CO_2 + I_2 + H_2SO_4 + SO_3$ . The color imparted to the granules, unless produced by high concentrations of carbon monoxide, fades rapidly after each test, and a tube ordinarily may be used seven or eight times before its effectiveness is destroyed. Exhaustion of the material in the tube is indicated when the usual color fails to fade or has a yellowish discoloration.

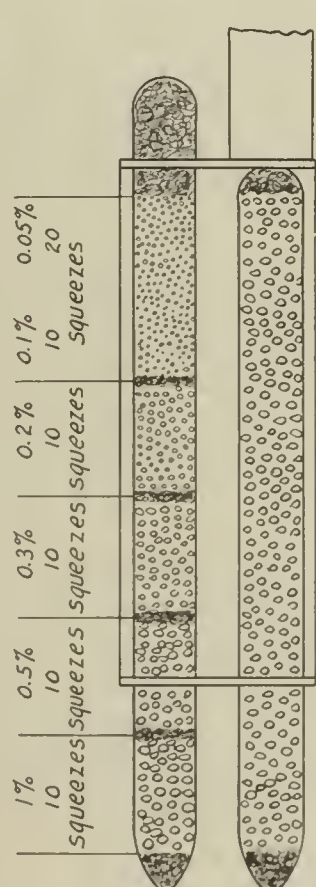
The mixture of iodine pentoxide and fuming sulphuric acid deteriorates if subjected to moisture, hence the tubes are furnished by the manufacturer drawn to a tip at each end and hermetically sealed. These tips are broken off just before the tube is inserted in the instrument for use. Each tube also has a shoulder at one end which fits into a rubber connecting joint (Fig. 1, DN-24).

A second glass tube containing five shades of permanently colored pumice stone is mounted beside that containing the patented mixture. These shades correspond to colorations produced when definite amounts of air containing 0.1, 0.2, 0.3, 0.5, and 1.0 per cent of carbon monoxide, respectively, are forced through hoolamite. Thus, a quantitative determination of the amount of carbon monoxide in the mine air can be made by squeezing the aspirator bulb the number of times (usually 10) needed to furnish the amount of air for which the permanent colors are calibrated and then comparing the resulting color with those in the color scale. If such a test indicates that the amount of carbon monoxide present is not within the calibrated range a fairly accurate determination can be made by squeezing the aspirator bulb some multiple of the usual number of times and making a corresponding correction in the percentage of carbon monoxide indicated by the color tube.

Other gases and vapors, such as ethylene, gasoline, hydrogen chloride, hydrogen sulphide, and the higher hydrocarbons of natural gas, if permitted to pass through the glass tube would also cause color changes in the iodine pentoxide mixture; therefore, the detector has a nicked cylinder (Fig. 1, DN-7) containing chemically treated or "activated" charcoal which removes such undesirable gases as the air to be tested is drawn through it. The chemically treated charcoal eventually becomes saturated with these gases and requires replacement. Saturation is indicated by coloration of fresh hoolamite when pure air is forced through it. The inlet end of the nicked cylinder has a corrugated tip to which a rubber hose may be attached. If the other end of such a hose is connected with a pipe leading through the stopping of a sealed area the percentage of carbon monoxide in the air behind the seal may be ascertained. Determinations of this sort are particularly useful during the work of fighting mine fires.



1%	0.5%	0.3%	0.2%	0.1%	0.05%
10	10	10	10	10	20
squeezes	squeezes	squeezes	squeezes	squeezes	squeezes



DN-19- color scale and hoolamite tube holder  
 DN-24- rubber connecting joint  
 DN-4- hoolamite tube

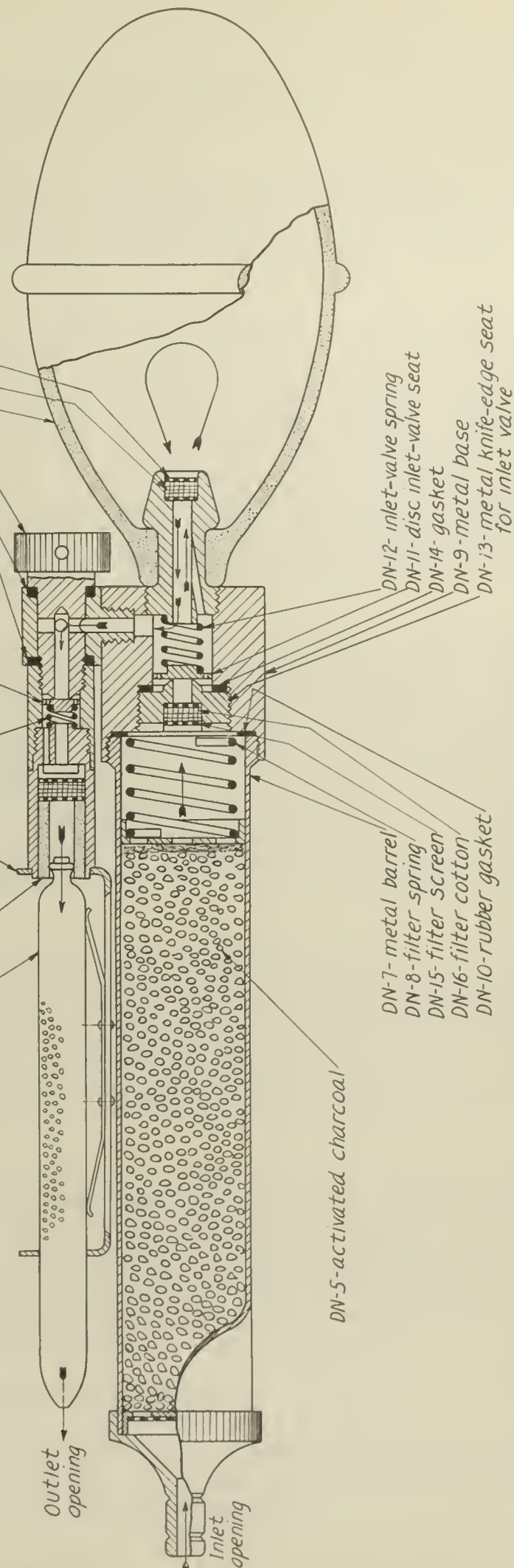


Figure 1- "Iodine pentoxide" detector for carbon monoxide.



Inspecting the Detector Before Use

Before the detector is taken underground it should be carefully inspected to make sure that the aspirator bulb does not leak and has the proper resilience, that the valves of the instrument are tight and function properly, that the color tube is held securely in place, and that the activated charcoal is in good condition.

When the aspirator bulb (Fig. 1, DN-6) is squeezed a current of air should issue from the rubber connecting joint (Fig. 1, DN-24) into which the hoolamite tube is to be inserted; and when the bulb is released a current of air should enter the inlet opening at the end of the nicked charcoal container (Fig. 1, DN-7). Hence, the condition of the bulb may be determined by testing it with both of these openings closed. If the bulb is sound it can not be squeezed flat; if it lacks resilience, it will not go back into shape promptly after being collapsed. A bulb that is found to be defective should be removed and replaced. The bulb may be removed by grasping the nicked charcoal container with one hand and giving a twisting pull on the bulb with the other.

If the inlet valve is tight, no air will be lost when the aspirator bulb is squeezed as long as a finger is held tightly over the opening in the rubber connecting joint (Fig. 1, DN-24). If the valve is functioning properly and the inlet aperture is open the aspirator bulb after being collapsed will refill rapidly as soon as the hand pressure is withdrawn. The parts of an inlet valve that leaks or sticks may be made accessible for cleaning or repairing by unscrewing the charcoal container and removing the inlet valve-seat (Fig. 1, DN-11) with a screw driver. The metal valve seat can then be wiped clean with a cloth. In reassembling care should be taken to replace the spring (Fig. 1, DN-12) in the proper position to hold the valve seat in place.

If the outlet valve is tight and the inlet aperture is closed the aspirator bulb should remain collapsed when the pressure that deflated it is released. To reach the outlet-valve parts for cleaning or repairing, remove the charcoal container and unscrew the metal holder (Fig. 1, DN-13) that carries the color scale and hoolamite tubes. The spring in this metal holder should be adjusted to hold the tubes in place, even when the instrument is grasped by the aspirator bulb and shaken roughly.

The freshness of the chemically treated charcoal may be tested by inserting an unused hoolamite tube in the instrument and squeezing the bulb 20 times in pure air. If the material in the tube becomes discolored under these conditions the charcoal container should be refilled with fresh activated charcoal supplied by the manufacturer. In reassembling the instrument, care should be taken to replace the spring (Fig. 1, DN-3) that holds the charcoal in place correctly, otherwise air channels through the charcoal might result.

Use of the Detector in Mines

Assuming that the operator is protected by a suitable gas mask or other apparatus when working in an atmosphere liable to contain carbon monoxide, he should use the detector in the mine in the following manner:



1. Squeeze the bulb once or twice to remove any moisture and to fill the instrument with air identical with that to be tested.

2. Break both tips of a hoolamite tube and insert it firmly in the instrument with the shoulder securely seated in the rubber connecting joint.

3. Squeeze the bulb 10 times in succession, collapsing it completely each time. This will force about 350 cubic centimeters of air through the impregnated pumice. A slight amount of smoke or fume should issue from the hoolamite tube when the bulb is squeezed. Although this smoke is harmful if breathed directly, under ordinary conditions it will be so quickly diluted by the mine air that no symptoms other than coughing are likely to be noted. Observation of the smoke, however, is often advantageous as indicating the direction and velocity of the ventilating current in the mine.

4. After squeezing the bulb the full number of times, compare the resulting color (if any) with the permanent colors in the color tube and note the corresponding percentage of carbon monoxide. At low concentrations of carbon monoxide the color in the hoolamite tube fades rapidly, hence the comparison with the color tube should be made at once.

5. If no color comparable with those in the color tube results from 10 squeezes repeat the test, using some multiple of 10 and making the corresponding correction in the percentage indicated by the color obtained. For example, if a color corresponding to that for 0.1 per cent is obtained with 20 successive squeezes the amount of carbon monoxide in the air sampled is about 0.05 per cent; or, if a color corresponding to that for 1.0 per cent is obtained with 5 squeezes, approximately 2.0 per cent of carbon monoxide is indicated in the mine air. As stated, the operator should be protected by a gas mask or breathing apparatus when working in anything like a 2 per cent concentration of carbon monoxide.

6. Remove the hoolamite tube from the instrument promptly, as it should not be left in place longer than the time necessary to make the test. If the color in the tube does not fade or if a yellow discoloration appears, the tube should be discarded. As the iodine pentoxide mixture is highly acid a discarded tube should not be thrown where it can do any damage. If the tube is to be used again the tips should be covered with rubber caps to prevent deterioration of the contents through entrance of moisture.

#### Conclusion

One should recognize that the detector does not indicate a deficiency of oxygen in the atmosphere or the presence of such other gases as carbon dioxide and hydrogen sulphide; nor does it automatically give warning of carbon monoxide as the operator may actually be in an atmosphere containing this gas without using the instrument. Hence, in these respects, the detector is inferior to canary birds or mice. However, when in good condition and used in the manner outlined above, the detector affords a reasonably accurate quantitative means of determining, while

underground, the percentage of carbon monoxide in the air, which it is impossible to do with small animals. Also, birds or mice should be returned to fresh air to revive them after being overcome by carbon monoxide, whereas use of the detector permits a rescue crew to proceed without delay, and additional tests for carbon monoxide can be made as the work progresses. Furthermore, the instrument is light, compact, and easily carried in the mine, needs little attention, and requires no special ability or skill for operation other than that of distinguishing between different shades of color. All of these advantages make the detector an extremely valuable tool for use by men in mine rescue and recovery work or by any others who must breathe air in which carbon monoxide may be found.-- Information Circular, Bureau of Mines, Department of Commerce.





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INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE - BUREAU OF MINES

LIST OF PERMISSIBLE MINING EQUIPMENT<sup>1</sup>

A complete list of permissible mining equipment, rescue apparatus and gas masks tested prior to July 2, 1927, was published in Bureau of Mines Information Circular 6047<sup>2</sup>. The present list includes all equipment tested and approved by the Bureau, up to and including January 1, 1928. It covers electric air compressors, coal drills, mining machines, loading machines, conveyors, mine pumps, room hoists, mine telephones, rock-dusting machines, switches, electric cap lamps, flame safety lamps, electric hand and trip lamps, flash lamps, methane indicators and detectors, blasting units, storage battery locomotives, tandem locomotives, power trucks, concrete mixers, self-contained oxygen breathing apparatus and gas masks.

The system under which these devices were tested permits the manufacturer, after his equipment has passed certain tests prescribed by the Bureau of Mines, to mark his equipment with a seal showing that it has been "approved" by the Bureau. These tests are designed to insure that the equipment has the minimum requirements for safety in use. The only object of the Bureau in making such tests and publishing lists of permissible equipment is to safeguard the lives of workers and to help lessen the hazards of mining.

PERMISSIBLE MINING MACHINES, COAL DRILLS, ETC.

Approved Under Schedules 2, 2A, and 2B.

Air Compressors

1. Type WK-26 compressor; 30-hp. motor, 250-500 volts, D. C. Approvals No. 117 and 117A, issued to Sullivan Machinery Co., Mar. 12, 1925.
2. Type WK-39 self-propelled compressor; 30-hp. motor, 250-500 volts, D. C. Approvals No. 120 and 120A, issued to Sullivan Machinery Co., July 23, 1925.
3. Type CP-26G, CP-26D and CP-26H compressors; 25-hp. motor, 250-500 volts, D. C. Approvals No. 128 and 128A, issued to General Electric Co., March 21, 1927, and July 16, 1926, respectively.

<sup>1</sup> This article is not subject to copyright. Reprinting, with customary acknowledgment to the Bureau of Mines, will be welcomed.

<sup>2</sup> List of Permissible Mining Equipment, Information Circular No. 6047, Bureau of Mines, August 1927.

Loading Machines and Conveyors

1. Type 43-A shortwaloader; Jeffrey 50-hp. motor, 250-500 volts D. C. Approvals No. 122 and 122A, issued to The Jeffrey Mfg. Co., Jan. 8, 1926.
2. Type 44-B conveyor-loader; Jeffrey 50-hp. motor, 250-500 volts, D. C. Approvals No. 123 and 123A, issued to The Jeffrey Mfg. Co., Jan. 15, 1926.
3. Belt-type conveyor; South Fork Foundry & Machine Co. 5-hp. motor, 250 volts, D. C. Approval No. 126, issued to Bird Coal Co., June 25, 1926.
4. Shovel-type loading machine; General Electric motor 30-hp., 250 volts, D. C. Approval No. 127, issued to Myers-Whaley Co., July 16, 1926.
5. Chain-type conveyor; South Fork Foundry & Machine Co. 5-hp. motor, 250 volts, D. C. Approval No. 129, issued to the Bird Coal Co., July 21, 1926.
6. Type 5-BU loading machine; Crocker Wheeler 25-hp. motor, Ward Leonard Controller 230-500 volts, D. C. Approvals No. 132 and 132A issued to Joy Mfg. Co., December 29, 1926, and March 22, 1927, respectively.
7. Type 49-A chain-type conveyor; Jeffrey 3-hp. motor, 250-500 volts, D. C. Approvals No. 133 and 135A, issued to The Jeffrey Mfg. Co., Feb. 10, 1927.
8. Conveyor-type loader; General Electric 30-hp. motor, 250-500 volts, D. C. Approvals No. 135 and 135A, issued to the Sullivan Machinery Co., May 11, 1927.
9. Type 136-EC Entryloader; Goodman 35-hp. motor, 210-500 volts, D. C. Approvals No. 138 and 138A issued to the Goodman Mfg. Co., Aug. 5, 1927.
10. Belt-type conveyor; South Fork Foundry & Machine Co. 1-hp. motor, 220 volts, D. C. Approval No. 139 issued to the Lorain Steel Co., Aug. 19, 1927.

Coal Drills

1. Type 2-BF drill; 1-hp. motor, 80-110-250 volts, D. C. Approvals No. 109 and 109A, issued to Chicago Pneumatic Tool Co., Sept. 19, 1922.
2. Type CD drill; 3/4-hp. motor, 110-230 volts, D. C. Approvals No. 110 and 110-A issued to Martin-Hardsocg Co., Sept. 16, 1922.
3. Type A-5 drill; 3-hp. motor, 110-250 volts, D. C. Approvals No. 119 and 119-A issued to Jeffrey Mfg. Co., Apr. 15, 1925.

Mining Machines

1. Type CE-7 Ironclad shortwall mining machine; 30-hp. motor, 250-500 volts, D. C. Approvals No. 100 and 100A, issued to Sullivan Machinery Co., Sept. 30 and Oct. 20, 1914, respectively.

2. Types 12-CC and 12-EC shortwall mining machines, 35-hp. motor, 210-500 volts, D. C. Approvals No. 101 and 101A, issued to Goodman Mfg. Co., May 20, 1916.
3. Type 35-B shortwall mining machine, 35-hp. motor, 250-500 volts D. C. Approvals 103 and 103A, issued to The Jeffrey Mfg. Co., Nov. 2, 1917.
4. Type CE-7 Ironclad shortwall mining machine, 30-hp. motor, 220-440 volts, A. C. Approvals 104 and 104A, issued to Sullivan Machinery Co., Jan. 16, 1919.
5. Types 12-CJ and 12-EJ shortwall mining machines, 50-hp. motor, 210-500 volts, D. C. Approvals No. 105 and 105A, issued to Goodman Mfg. Co., June 21, 1920.
6. Types 112-CC and 112-EC shortwall mining machines, 50-hp. motor, 210-500 volts, D. C. Approvals 106 and 106A, issued to Goodman Mfg. Co., Feb. 9, 1922.
7. Types 12-CC and 12-EC shortwall mining machines, 35-hp. motor, 210-500 volts, D. C. Approvals No. 107 and 107A, issued to Goodman Mfg. Co., Feb. 9, 1922.
8. Types 112-CJ and 112-EJ shortwall mining machines, 35-hp. motor, 210-500 volts, D. C. Approvals No. 108 and 108A, issued to Goodman Mfg. Co., Feb. 9, 1922.
9. Type 35-BB shortwall mining machine, 50-hp. motor, 250-500 volts, D. C. Approvals No. 111 and 111A, issued to Jeffrey Mfg. Co., Oct. 16, 1922.
10. Type 29-C arcwall mining machine, 50-hp. motor, 250-500 volts, D. C. Approvals No. 112 and 112A, issued to Jeffrey Mfg. Co., Mar. 13, 1924.
11. Types 212-EJ and 212-CJ shortwall mining machines; 50-hp. motor, 210-500 volts, D. C. Approvals No. 113 and 113A, issued to Goodman Mfg. Co., Nov. 4, 1924.
12. Types 112-CK3 and 112-EK3 mining machines; 35-hp. motor, 220-440 volts, A. C. Approvals No. 114 and 114A, issued to Goodman Mfg. Co., Feb. 7, 1925.
13. Types 112-CL3 and 112-EL3 shortwall mining machines, 50-hp. motor, 220-440 volts, A. C. Approvals No. 115 and 115A, issued to Goodman Mfg. Co., Feb. 7, 1925.
14. Type 124-EJ slabbing machine; 50-hp. motor, 210-500 volts, D. C. Approvals No. 118 and 118A, issued to Goodman Mfg. Co., Mar. 12, 1925.
15. Type 30-A shearing-drilling machine; 50-hp. motor, 250-500 volts, D. C. Approvals No. 125 and 125A, issued April 26, 1926 to The Jeffrey Mfg. Co.
16. Type CLU cutting-shearing machine; 30-hp. motor, 250-500 volts, D. C. Approvals No. 134 and 134A, issued to the Sullivan Machinery Co., March 18, 1927.
17. Type CLE longwall mining machine; 30-hp. motor, 250-500 volts, D. C. Approvals No. 136 and 136A, issued to the Sullivan Machinery Co., May 28, 1927.



Room Hoists

1. Oaks safety room hoist; 5-hp. motor, 250-500 volts, D. C. Approval No. 116 and 116A, issued to South Fork Foundry & Machine Co., Feb. 13, 1925.

Mine Pumps

1. Dravo-Doyle mine pump Type Austin 5 x 6, 5-hp. General Electric motor and control, 500 volts, D. C. Approval No. 121-A, issued to Dravo-Doyle Co., Oct. 1, 1925.
2. Dravo-Doyle mine pump; Type Austin 5 x 6, 5-hp. Westinghouse motor and control, 250-500 volts, D. C. Approvals No. 124 and 124A, issued to Dravo-Doyle Co., April 14, 1926.
3. Fairmont No. 1 mine pump; Westinghouse 5 H.P. motor and control, 115, 230 and 500 volts, D. C. Approvals No. 140 and 140A, issued to Westinghouse Electric & Mfg. Co., Nov. 1, 1927.
4. Deming "Oil Rite" mine pump; Westinghouse 5 H.P. motor and control, 115, 230 and 500 volts, D. C. Approvals No. 141 and 141A, issued to Westinghouse Electric & Mfg. Co., Nov. 1, 1927.
5. Scranton 5 x 6 mine pump; Westinghouse 5 H.P. motor and control, 115, 230 and 500 volts, D. C. Approvals No. 143, and 143A issued to Westinghouse Electric & Mfg. Co., Nov. 1, 1927.
6. Weinman "Self-Oiler" mine pump; Westinghouse 5 H.P. motor and control, 115, 230 and 500 volts, D. C. Approvals No. 144 and 144A issued to Westinghouse Electric & Mfg. Co., Nov. 1, 1927.
7. Dravo-Doyle mine pump; Type Austin 5 x 6; Westinghouse 5 H.P. motor and control; 115, 230 and 500 volts, D. C. Approvals No. 145 and 145A issued to Westinghouse Electric & Mfg. Co., Nov. 18, 1927.

Concrete Mixers

1. Consolidation Coal Co. Austin type concrete mixer; Westinghouse 5 H.P. motor and control, 115, 230 and 500 volts, D. C. Approvals No. 142 and 142A issued to Westinghouse Electric & Mfg. Co., Nov. 1, 1927.

Rock-Dusting Machines

1. Mine Safety Appliances Co., rock-dusting machine; Westinghouse 5-hp., 230-volt motor and control, Mancha headlight. Approval No. 130, issued to Mine Safety Appliances Co., November 5, 1926.

2. Diamond Machine Co., rock-dusting machine; Jeffrey 15-hp., 230-volt motor and control. Approval No. 131, issued to Diamond Machine Co., December 28, 1926.
3. Mine Safety Appliances Co., rock-dusting machine, Jeffrey 15-hp. 230-volt motor and control, Mancha headlight. Approval No. 137 issued to Mine Safety Appliances Co., July 2, 1927.

#### PERMISSIBLE ELECTRIC SWITCHES AND JUNCTION BOXES

##### Approved Under Schedule 4A

1. Enclosed two-pole fused switch - 100 amperes, 500 volts, D. C. Approval No. 400A issued to Ohio Brass Co., August 5, 1925.
2. Enclosed two-pole fused switch - 250 amperes, 250 volts; 150 amperes, 500 volts D. C. Approvals No. 401 and 401A issued to the Sullivan Machinery Co., May 11, 1927.
3. Enclosed 3-pole fused switch - 250 amperes, 220 volts; 150 amperes, 440 volts, A. C. Approvals No. 402 and 402A issued to the Sullivan Machinery Co., May 11, 1927.

#### PERMISSIBLE ELECTRIC CAP LAMPS FOR MINERS

##### Approved Under Schedules 6A & 6B

1. Edison Model "C" lamp. Approval No. 10, issued to Edison Storage Battery Co., Feb. 24, 1915.
2. Wico lamp, Approval No. 14, issued to Witherbee Igniter Co., June 10, 1916.
3. Wheat lamp. Approval No. 17, issued to Koehler Mfg. Co., Inc., Sept. 23, 1919.
4. Edison Model "E" lamp. Approval No. 18, issued to Edison Storage Battery Co., March 28, 1923.
5. RM-6 f. d. Ceag lamp. Approval No. 19, issued to Concordia Electric Co., Aug. 2, 1923.
6. Super-Wheat lamp. Approval No. 20, issued to Koehler Mfg. Co., Inc., Apr. 27, 1926.
7. RM-7 Ceag lamp. Approval No. 21, issued to Concordia Elec. Co., June 18, 1926.
8. Edison Model G lamp, Approval No. 22 issued to Edison Storage Battery Co., Nov. 16, 1927.

## PERMISSIBLE FLAME SAFETY LAMPS

### Approved under Schedules 7, 7A and 7B.

1. Koehler steel frame lamp, flat wick. Approval No. 201, issued to Koehler Mfg. Co., Inc., Aug. 21, 1915.
2. Koehler Steel frame lamp, round wick. Approval No. 201A, issued to Koehler Mfg. Co., Inc., July 29, 1918.
3. Koehler Aluminum frame lamp, flat wick. Approval No. 203, issued to Koehler Mfg. Co., Inc., Feb. 7, 1919.
4. Koehler Aluminum frame lamp, round wick. Approval No. 203A, issued to Koehler Mfg. Co., Inc., Feb. 7, 1919.
5. Wolf brass frame lamp, round wick. Approval No. 204, issued to Wolf Safety Lamp Co. of America, Inc., July 18, 1921.
6. Wolf Aluminum frame lamp, round wick. Approval No. 205, issued to Wolf Safety Lamp Co. of America, Inc., Apr. 24, 1924.
7. Wolf Aluminum frame lamp, flat wick. Approval No. 206, issued to Wolf Safety Lamp Co. of America, Inc., Apr. 24, 1924.
8. Wolf brass frame lamp, flat wick. Approval No. 207, issued to Wolf Safety Lamp Co. of America, Inc., March 14, 1927.

## PERMISSIBLE ELECTRIC HAND AND TRIP LAMPS

### Approved Under Schedule 10A

1. Type RMC-RMCT Ceag hand and trip lamp. Approval No. 1000, issued to Concordia Electric Co., May 25, 1922.
2. Model "E" inspection lamp. Approval No. 1001, issued to Mine Safety Appliances Co., July 28, 1925.
3. Model "E" signal lamp. Approval No. 1002 issued to Mine Safety Appliances Co., December 8, 1927.

## PERMISSIBLE ELECTRIC FLASH LAMPS

### Approved Under Schedule 11

1. Eveready, safety type, flash lamp. Approval No. 601, issued to National Carbon Co., Inc., Oct. 22, 1924.



PERMISSIBLE METHANE INDICATORS AND DETECTORS

Approved Under Schedules 7B and 8A

Methane Indicating Detectors

1. Burrell indicator. Approval No. 800 issued to Mine Safety Appliances Company, March 10, 1922.

Methane Detectors

1. Wolf flame-type detector. Approval No. 207, issued to Wolf Safety Lamp Co. of America, Inc., Nov. 21, 1924.

PERMISSIBLE MINE TELEPHONES

Approved Under Schedule 9A

1. Redesigned Type No. 1336 Mine telephone. Approval No. 901 issued to the Western Electric Co., Inc., July 16, 1927.

PERMISSIBLE SINGLE-SHOT BLASTING UNITS

Approved Under Schedule 12

1. Attachment for Edison M-8 mine lamp battery. Approval No. 1200, issued to Mine Safety Appliances Co., May 24, 1920.
2. Davis No. 0 magneto-type blaster. Approval 1201, issued to Davis Instrument Mfg. Co., (Inc.) Mar. 15, 1921.
3. Du Pont pocket magneto type blaster. Approval No. 1202, issued to E. I. Du Pont de Nemours & Co., Aug. 15, 1924.
4. Davis No. 00 magneto-type blaster. Approval No. 1203, issued to Davis Instrument Mfg. Co. (Inc.) Oct. 17, 1924.
5. Attachment for Concordia Type RM-6 f.d. mine lamp battery. Approval No. 1204, issued to the Concordia Electric Co., Mar. 2, 1925.
6. Attachment for Edison Model "E" lamp battery. Approval No. 1205, issued to the Mine Safety Appliances Co., April 28, 1925.
7. Eveready dry cell blaster. Approval No. 1206, issued to National Carbon Co., (Inc.) Aug. 20, 1925.
8. Davis No. 000 magneto-type blaster. Approval No. 1207 issued to Davis Instrument Manufacturing Co., Inc., Nov. 18, 1926.

PERMISSIBLE STORAGE BATTERY LOCOMOTIVES AND POWER TRUCKS

Approved Under Schedule 15

Gathering Locomotives

1. Whitcomb E.S.B. flame-proof locomotive. Approval No. 1500, issued to Geo. D. Whitcomb Co., May. 14, 1921. The following batteries are optional\*: 80 cells Edison G-14, 96 cells Edison A-10, 48 cells Gould, 29 plate.
2. Jeffrey type B.D.M. class 40 locomotive. Approval No. 1501, issued to The Jeffrey Manufacturing Co., October 11, 1921. The following batteries are optional\*: 80 cells, Edison A-12, 88 cells Edison A-12, 104 cells Edison A-12, 49 cells Phila. 33 plate, 48 cells Exide 21 plate, 80 cells Edison A-8.
3. Mancha flame-proof "Hercules" locomotive. Approval No. 1502, issued to the Mancha Storage Battery Locomotive Co., Nov. 13, 1922. The following batteries are optional\*: 48 cells Phila. 33 plate, 48 cells Phila. 39 plate, 48 cells Gould 33 plate, 48 cells Exide 27 plate.
4. Iron-ton type W.O.G. locomotive. Approval No. 1503, issued to Iron-ton Engine Co., Mar. 24, 1923. The following batteries are optional\*: 88 cells Edison A-10, 49 cells Phila. 33 plate, 48 cells Phila. 33 plate.
5. Goodman articulated type locomotive. Approval No. 1504, issued to Goodman Mfg. Co., July 10, 1923. Battery, 134 cells Edison A-8.
6. Mancha Hercules A and AX locomotives. Approval No. 1505, issued to the Mancha Storage Battery Locomotive Co., April 5, 1924. The following batteries are optional\*: 54 cells 33 plate Exide, 54 cells Phila. 39 plate, 90 cells Edison A-12, 92 cells Edison A-10.
7. Jeffrey type B.D.M. Class 25 locomotive. Approval No. 1507, re-issued to The Jeffrey Mfg. Co., Aug. 20, 1925. The following batteries are optional\*: 54 cells 33 plate Exide, 54 cells Phila. 39 plate, 54 cells Phila. 33 plate, 48 cells K.W. 37 plate; 49 cells Exide 27 plate.
8. Goodman Type 10-30 locomotive. Approval No. 1508, issued to the Goodman Mfg. Co., Mar. 21, 1925. The following batteries are optional\*: 48 cells Exide 33 plate, 48 cells Phila. 39 plate.
9. Goodman Type 8-30 locomotive. Approval No. 1509, issued to the Goodman Mfg. Co., Sept. 25, 1925. Battery 48 cells Exide 23 plate.

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\* This includes all batteries covered by the original approval or extensions of approval prior to Jan. 1, 1923.

10. Mancha Standard A, AN and AX locomotives. Approval No. 1511, issued to Mancha Storage Battery Locomotive Co., Nov. 10, 1925. The following batteries are optional:\* 48 cells Phila. 23 plate, 48 cells Phila. 29 plate, 49 cells Phila. 29 plate; 48 cells Exide 19 plate; 48 cells Exide 23 plate; 56 cells Phila. 15 plate; 80 cells Edison A-8.
11. Westinghouse-Baldwin locomotive. Approval No. 1512, issued to Westinghouse Electric & Mfg. Co., Nov. 11, 1925. The following batteries are optional:\* 80 cells Edison A-8; 48 cells Exide 19 plate; 48 cells Exide 27 plate.
12. General Electric type LSBE-206-C9 locomotive. Approval No. 1513, issued to General Electric Co., February 25, 1926. The following batteries are optional:\* 48 cells Exide 27 plate, 80 cells Edison A-12; 48 cells Exide 33 plate.
13. Jeffrey Type B.D.M. 25 Form H Locomotive. Approval No. 1516, issued to The Jeffrey Mfg. Co., December 28, 1926. Battery, 48 cells Exide 33 plate; 54 cells Phila. 39 plate; 54 cells Exide 33 plate.
14. Atlas Type B locomotive. Approval No. 1517, issued to Atlas Car & Mfg. Co., Feb. 10, 1927. Battery 48 cells Phila. 39 plate.

#### Main Line Haulage Locomotive

1. Jeffrey Type B.D.M. Class 30 main line haulage locomotive. Approval No. 1510 issued to Jeffrey Mfg. Co., Oct. 12, 1925. The following batteries are optional:\* 110 cells Phila. 39 plate, 110 cells Exide 33 plate; 117 cells Exide 33 plate.

#### Power Trucks

1. Mancha power tank. Approval No. 1506, issued to Mancha Storage Battery Locomotive Co., May 5, 1924. The following batteries are optional:\* 110 cells Phila. 29 plate, 110 cells Phila. 31 plate, 117 cells Phila. 27 plate, 110 cells Exide 27 plate, 117 cells Exide 23 plate.
2. Mancha power tank and gathering locomotive. Approval No. 1505A, issued to Mancha Storage Battery Locomotive Co., June 21, 1926. Battery 117 cells Phila. 19 plate; 56 cells Phila. 35 plate; 56 cells K.W. 35 plate; 56 cells Exide 29 plate.
3. Jeffrey power truck and main line haulage locomotive. Approval No. 1510-C, issued to The Jeffrey Manufacturing Co., Dec. 31, 1926. Battery 117 cells Phila. 39 plate.

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\* This includes all batteries covered by the original approval or extensions of approval prior to Jan. 1, 1928.



4. Mancha non-propelled power truck, Approval No. 1514, issued to Mancha Storage Battery Locomotive Co., December 18, 1926. The following batteries are optional:\* 110 cells 27 plate Exide, 117 cells 23 plate Exide, 110 cells Phila. 31 plate, 117 cells Phila. 27 plate.
5. Jeffrey Power truck. Approval No. 1515, issued to The Jeffrey Mfg. Co., December 23, 1926. Battery 117 cells Phila. 27 plate.

Tandem Locomotives

1. Jeffrey tandem locomotive. Approval No. 1518 issued to The Jeffrey Mfg. Co., Nov. 21, 1927. Battery 110 cells Phila. 23 plate.

PERMISSIBLE SELF CONTAINED OXYGEN BREATHING APPARATUS AND GAS MASKS

Approved Under Schedules 13 and 14A

Oxygen Breathing Apparatus

1. Gibbs mine rescue breathing apparatus. Approval No. 1300, issued to Mine Safety Appliances Co., January 15, 1920.
2. Paul mine rescue breathing apparatus. Approval No. 1301, issued to American Atmos Corp., January 15, 1920.
3. Fleuss-Davis Proto apparatus. Approval No. 1302, issued to Siebe, Gorman and Co., (Ltd.) February 7, 1924.
4. McCaa mine rescue breathing apparatus. Approval No. 1303, issued to Mine Safety Appliances Co., Aug. 31, 1925.

Gas Masks

1. Burrell ammonia gas masks. Approval No. 1401, issued to Mine Safety Appliances Co., April 10, 1920.
2. M. S. A. self-rescuer. Approval No. 1402, issued to Mine Safety Appliances Co., March 6, 1924.
3. All-service gas mask. Approval No. 1403, issued to Mine Safety Appliances Co., July 1, 1925.
4. G. M. D. ammonia gas mask. Approval No. 1404, issued to Mine Safety Appliances Co., March 10, 1926.
5. La France ammonia gas mask. Approval No. 1401, issued to American La France Fire Engine Co., Inc., June 23, 1927.

Information Circular, Bureau of Mines, Department of Commerce.

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\* This includes all batteries covered by the original approval or extensions of approval prior to Jan. 1, 1928.

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# STATE GEOLOGICAL SURVEY

## INFORMATION CIRCULAR

DEPARTMENT OF COMMERCE --- BUREAU OF MINES

### ACCIDENT PREVENTION MEASURES AT THE MOCTEZUMA COPPER COMPANY<sup>1</sup>

By: E. D. Gardner<sup>2</sup>

#### INTRODUCTION

The Moctezuma Copper Company, at Pilares, Sonora, Mexico, is making a noteworthy record in the prevention of accidents. In connection with an intensive educational campaign and systematic inspection many safety measures have been adopted which have proved of value.

#### MINING SYSTEM

The country rock is latite and andesite. The ore bodies occur around the rim of an oval about 1,200 feet long and 450 feet across in reconsolidated brecciated country rock. The mine is developed by means of shafts. The ore is now being mined mostly by inclined-rill, horizontal cut-and-fill, and square-set stopes. The ore is harder in the lower levels than in those nearer the surface, and most of the new stopes are being opened to be mined by the rill system. Six-foot cuts are taken at a time. Rounds are drilled with a new mounted, fast-drilling, light-weight Leyner-type machine. Stopers are used in the raises only. No dry drilling is done in the mines; if for any reason water is not available, all drilling ceases until it is available.

Practically all work at the mine is done under contract. Even hoist engineers are employed under this system. Each stope or development face is given to a contractor, who hires his own men with the approval of the foreman. Each division foreman gives the contracts and sets the unit rate for the work done for his part of the mine, based on the standard wage-scale.

#### ACCIDENT RATE

In 1925, three fatalities and 275 lost-time accidents occurred. During that year a concerted effort was started to reduce the number of accidents; in 1926 there were four fatalities and 78 lost-time accidents. Twenty-seven of these accidents caused more than two weeks and 51 less than two weeks lost time. Although the fatalities increased by one the total number of accidents was less than a third of the number for 1925. A total of 428,905 shifts was worked in 1926. Seven accidents, including one fatality, occurred in January, 1927; one

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accident in February; none in March, and one in April. The total number of accidents for 1927 was only a little more than half the number for 1926. No lost-time accidents occurred at the concentrating plant for over three years.

#### ACCIDENT-PREVENTION MEASURES

To keep the accident rate to a minimum at a mine it is necessary that the management be convinced that most if not all accidents can be prevented. Once the executives of a mine have determined to reduce the accident rate the next move is to convert the bosses to the idea of accident prevention, install safeguards, and change unsafe practices. The men can then be educated to do their work in a safe manner, and generally such education is largely a matter of discipline.

Safety rules are established at the Moctezuma mine, and in general are enforced. Workmen and bosses with good safety records receive extra consideration, while violators of safety rules are disciplined. The company gives a fiesta or holiday with suitable entertainment to the workmen whenever a 30-day period is completed underground without a lost-time accident.

Mining operations at this mine are planned to afford a maximum of safety to the workers; and only too frequently this phase of accident prevention in mines is ignored. Safeguards are installed where needed, the cause of each individual accident is studied, mining practices are improved where they are found deficient, and rules are established to prevent insofar as feasible recurrence of any particular type of accident.

The Moctezuma is a clean mine. Ladderways and drifts are kept in safe condition and free from broken or loose rock, ditches are kept clean, and no trash is allowed to accumulate underground. All timber and other supplies are promptly stored or utilized after being lowered. These and other similar measures undoubtedly have a favorable influence on maintaining a low accident rate.

#### Falls of Rock

Accidents from falls of rock are the most frequent in this mine; however, the rate has been greatly reduced by supervising the contractors more closely and requiring them to safeguard their workers by teaching them safe methods of work and the use of available safe equipment and devices.

The men on stope contracts are paid by the number of cars taken from the stope or for the cubic meters of ground broken. In addition, they are paid a contract price for placing cribs or stulls for supporting the back, as well as for building chutes, sorting ore, and other necessary operations looking to safety and efficiency. The facts that the company pays for work done to make the stopes safe and that time thus spent does not reduce the contractor's earnings are decidedly important in preventing accidents from falls of roof in the stopes of this mine. In this manner much of the objection to the contract system as to its effect on safety is overcome; in fact, under the system in vogue in this mine the individual worker is paid extra to enhance his own safety and that of fellow workers.



Hard-Boiled Hats

No one -- miner, manager, or visitor -- is allowed to go underground unless he is wearing the so-called "hard-boiled" hat. The company furnishes these hats to the men for 50 cents each and replaces damaged ones free of cost. This order has been in effect for over a year and, should it be rescinded, nearly all of the men would undoubtedly continue to wear such hats anyway. There is no question that compulsory use of the "hard-boiled" hat has had a decided influence toward reducing accidents from falls of rock.

On April 8, 1927, a piece of ore weighing 87 pounds fell through the top lagging in a square-set stope for a distance of 4 feet and struck a miner on the top of his head. The hat was crushed but the man's head was uninjured. Two weeks later he was still in the hospital with a sprained and stiff neck, but he was expected soon to be released. Seven other crushed hats are exhibited in a case near the collar of the shaft; each hat saved its wearer from a serious accident and at least one preserved his life.

Haulage

In most mines haulage accidents seem to be among the most difficult to prevent. At Pilares tracks and equipment are kept in good condition. The motors are equipped with bells, and the haulageways are large enough to allow a man to stand in the clear while trains are passing. A man afoot precedes all trains that are being pushed by motor.

Goggles

Eye accidents have been largely eliminated by the compulsory use of goggles. Every man whose duties are such that he might receive an eye injury must have a pair of goggles either around his neck or on his hat before he is lowered into the mine. Three pairs of goggles, which undoubtedly saved three men an eye each, are exhibited in a case near the shaft. In 1924, before the use of goggles was made compulsory, 102 eye accidents occurred; in 1926 there were only two such accidents, and undoubtedly the compulsory widespread use of goggles in the mine is responsible for practically all of the 1926 decrease in eye accidents.

Loading Chutes

The most common accident at loading chutes is crushed hands or fingers, and almost wholly with a view to reducing these accidents a second or safety gate is provided at Pilares on all loading chutes. The lower gate is opened to draw the chute; the second gate does not unduly retard the flow of ore but rides on top of the moving stream of ore and catches all flying particles, the ones which are most likely to cause accidents to the chute loaders. All chutes are drawn from platforms above the level of the top of the cars, and unquestionably the second gate on the chute has been the means of preventing a number of hand injuries.

Safety Belts

In this property it is not necessary that an accident shall occur before measures are taken to improve any operation in the mine that appears unsafe. Although no accidents had occurred in the gloryhole -- which furnished waste filling

in the mine -- the general superintendent issued an order that safety belts must be worn by all men working in the pit. Within six months a man fell, and undoubtedly his life was saved by the use of the belt.

#### CONCLUSIONS

The achievement in safety at the Moctezuma mine proves that accident rates can be held to a minimum when an intelligent and concerted effort is made to do so. Also it would appear that the class of labor employed does not have an important bearing on the frequency of the accidents and that excellent safety records can be obtained under the contract system of paying for work done, provided the contract system includes pay for safety work as well as for work in connection with production. - Information Circular, Bureau of Mines, Department of Commerce.





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